Tappi

PUBLISHED BY THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY

DECEMBER 1949

RESINS AND CHEMICALS

FOR THE PAPER INDUSTRY

BACTERICIDES AND DEODORANTS

HYAMINE 1622 and HYAMINE 2389 are quaternary ammonium germicides and deodorants used to produce bacteriostatic papers and paper board.

REDUCING AGENTS

Sodium and zinc hydrosulfites and their corresponding sulfoxylate formaldehydes are extremely powerful reducing agents used to bleach groundwood pulp at moderate temperatures and at low cost. They are also used to bleach kraft and semi-chemical pulps, and to strip the color from rags.

ENZYMES FOR STARCH CONVERSION

RHOZYME BB and RHOZYME E-5 are enzymes used in very small quantities to modify starch so that it may be used in surface sizes, adhesives, and coatings.

WETTING, DETERGENT, DISPERSING, AND EMULSIFYING AGENTS

THE TRITONS are synthetic, organic, surface-active agents used:

—to increase absorbency of towel stock
—to process raw cotton and rags
—to clean felts
—to de-ink waste paper
—to soften paper
—to improve the penetration of resins, sizes and salts
—to emulsify wax sizes, oily softening compounds, etc.
—to wet and disperse pigments
—to produce uniform coatings of glue on gummed paper and tape
—to control foam

TAMOL N is the neutral sodium salt of a complex, condensed organic acid. It is an efficient and economical means of dispersing pitch, of increasing the retention of fines, of precipitating glue, and dispersing pigments and clays in coatings.

AMBERLITE W-1

A 20 percent aqueous solution of a polymer which produces marked improvement in both the wet and dry physical properties of paper. The resin solution may be diluted and sprayed on the wet web, or applied at the size press or calender stacks. It is an excellent film-former and pigment-binder and exhibits remarkable quick-tack.

WET STRENGTH RESINS

UFORMITE—Urea formaldehyde resins in liquid and powder form, infinitely dilutible by water. Improve wet strength as well as the dry tensile, Mullen, and fold and pick resistance of paper.

TO MAKE YOUR GOOD PAPER BETTER

CHEMICALS FOR INDUSTRY

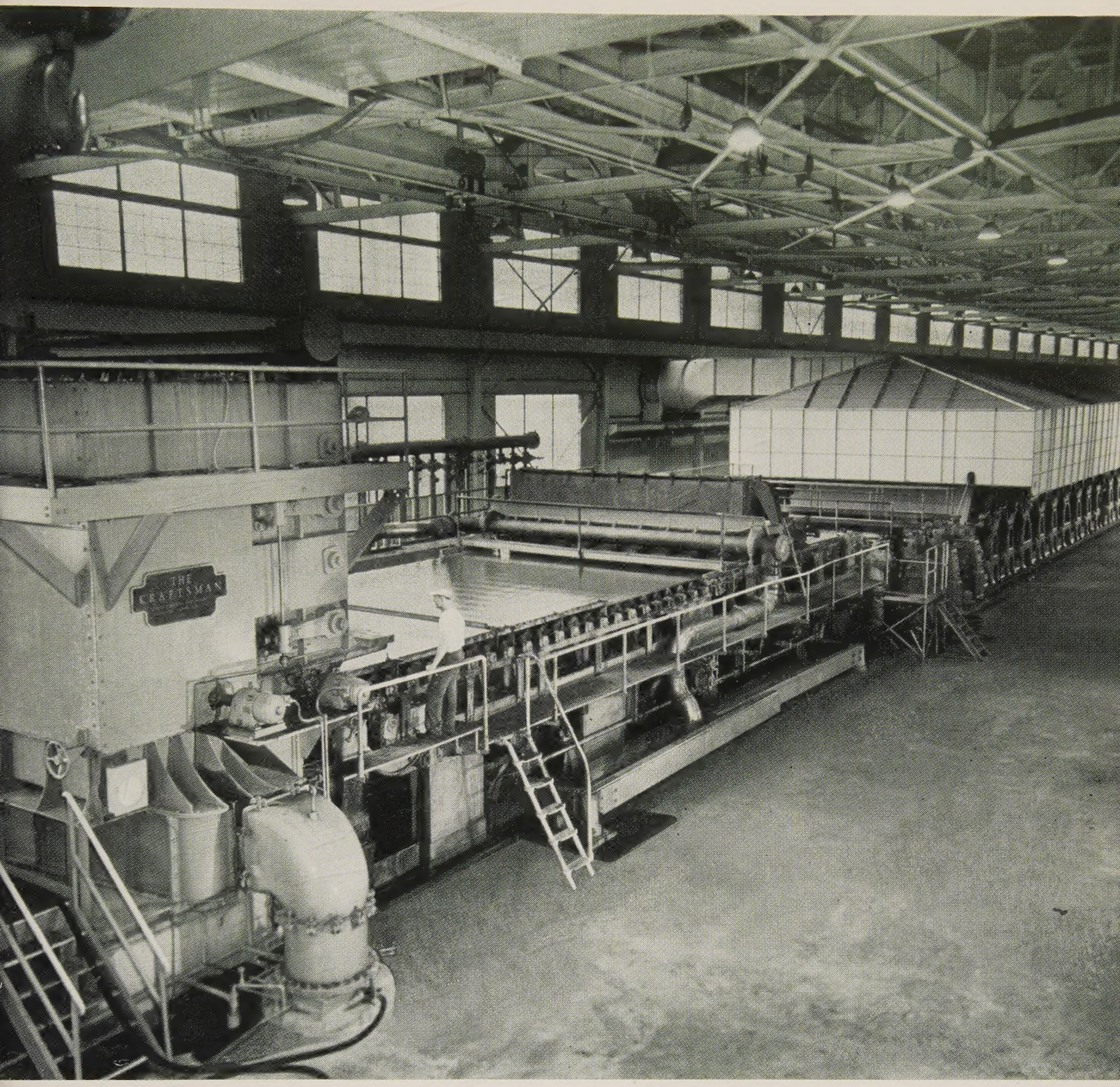
ROHM & HAAS COMPANY

THE RESINOUS PRODUCTS DIVISION

Washington Square Philadelphia 5, Pa.

The Resinous Products Division was formerly The Resinous Products & Chemical Company

North Carolina: kraft container and specialties



A long stride forward was taken by Kieckhefer Container Company's subsidiary, North Carolina Pulp Co., Plymouth, N. C., when in 1947 its huge expansion program climaxed in the start-up of "The Kraftsman"—216″ Beloit giant shown above. High speed and top quality production result from the combination of latest design improvements and paper-making skill. This year, a second phase of expansion was rounded out when the No. 2 machine was completely modernized by Beloit . . . builders of papermaking machinery since 1858.—*Beloit Iron Works, Beloit, Wisconsin.*

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For distinctive uniform tints with a minimum of two-sidedness, always specify

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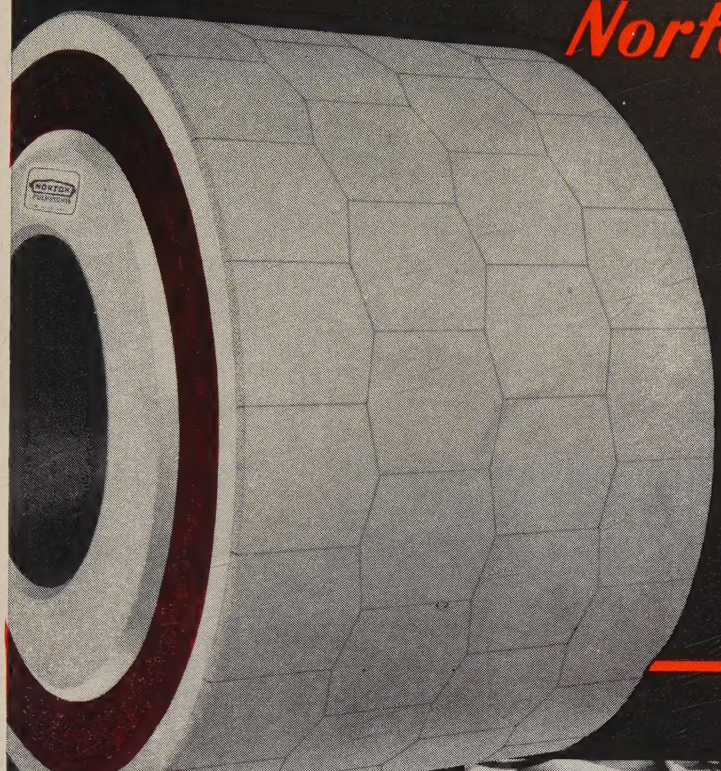
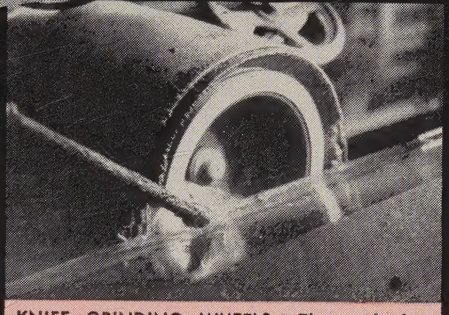


NORTON ENGINEERING SERVICE IS READY TO HELP YOU

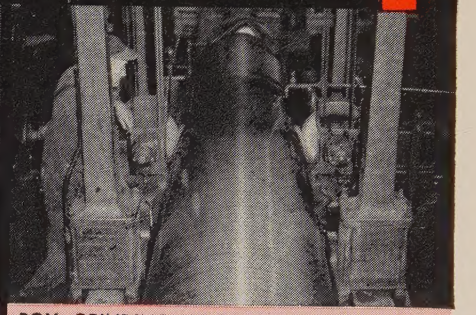
PULPSTONES—Available in the correct combination of abrasive, grit size, hardness and structure to meet *your* mechanical pulp requirements.

NORTON

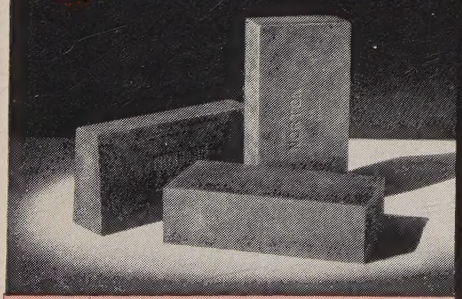
SAW GUMMING WHEELS — Available in vitrified or resinoid bond and several types of ALUNDUM abrasive to keep your rip, slasher and other saws in top-notch shape.



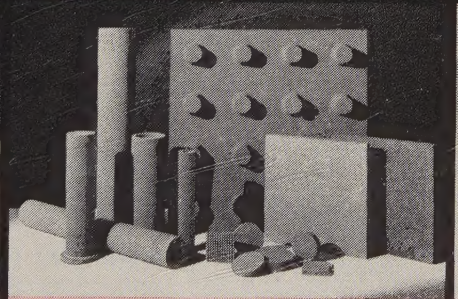
KNIFE GRINDING WHEELS — The cool, fast cutting action of the sensational 32 ALUNDUM abrasive is making it a favorite for all kinds of knife sharpening jobs.



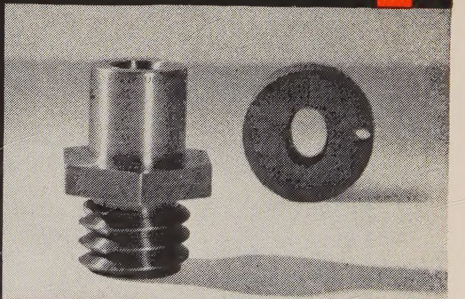
ROLL GRINDING WHEELS — Wheels of CRYSTOLON abrasive in vitrified, shellac and resinoid bonds to meet the requirements of all types of paper mill rolls.



REFRACTORIES—High temperature CRYSTOLON BRICK save money in boiler settings because of their long life, resistance to slag penetration and to abrasion.



POROUS MEDIUMS — Filter plates and diffusor tubes of carefully controlled permeability. Made of fused alumina (ALUNDUM) they combine strength and chemical stability.



DEBARKING NOZZLES—Made of Norton Boron Carbide (trademarked NORBIDE), the hardest material made by man, their life is many times that of other nozzles.

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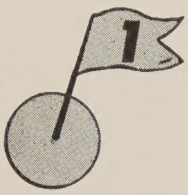
5 MONEY SAVING ADVANTAGES of the CONKEY INTEGRAL EVAPORATOR



Erection time generally *one quarter* that required for other types.

Vapor body, heating element, entrainment separator and flash chamber constructed in one common shell which is set into place in one operation.

As much as 30% reduction in floor space.

No external entrainment separators and flash chambers.

Negligible pressure drop.

Due to streamlining of design and integration of construction.

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Due to great reduction of pressure drop.

Minimum maintenance.

Design has eliminated many flanged joints and a space exists between shell and outer row of tubes wide enough for a man to walk through and inspect tubes.

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Blow Tanks	Evaporators	Bins
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Ask a General American engineer for more information on how these money saving advantages can be applied to your particular evaporation problem.

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DECEMBER 1949

Tappi

VOL. 32 · NO. 12

Published monthly by the Technical Association of the Pulp and Paper Industry

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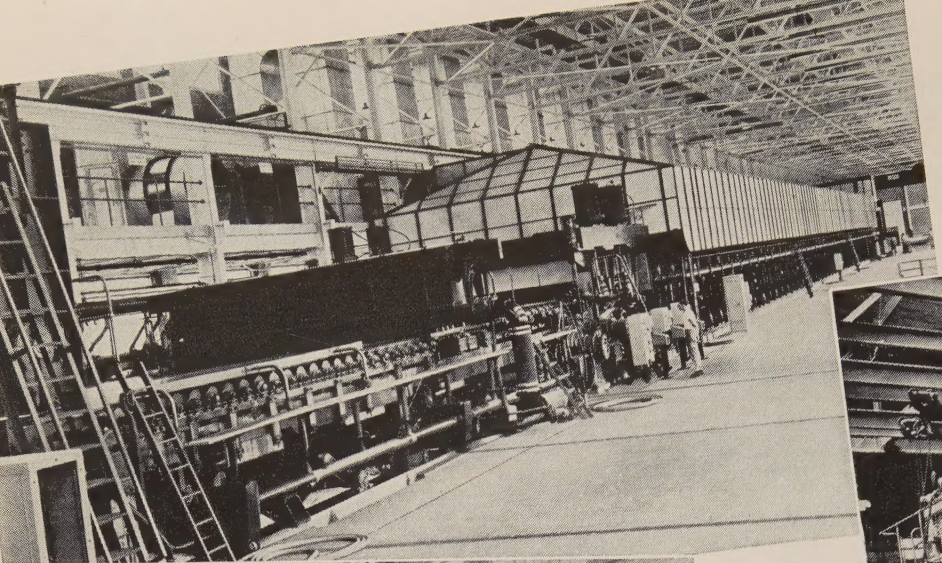
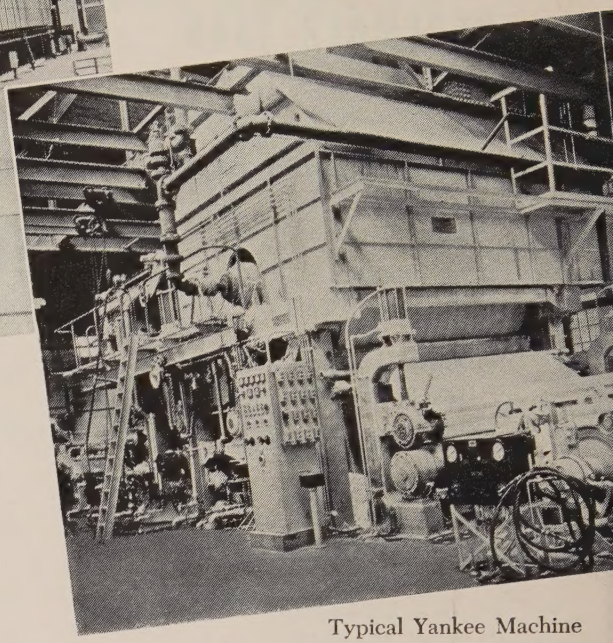
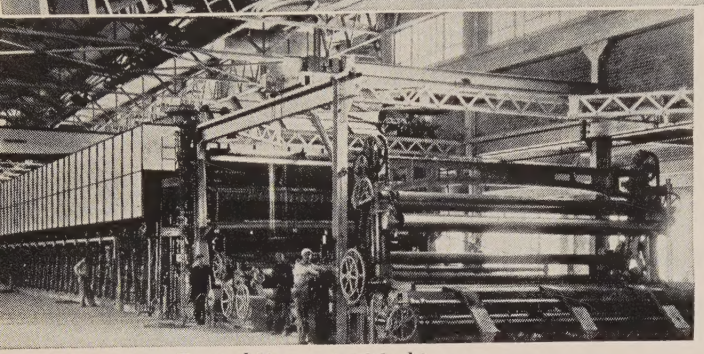
Published monthly by the Technical Association of the Pulp and Paper Industry at 20th and Northampton Streets, Easton, Pa. Editorial and advertising offices, 122 East 42nd Street, New York 17, N. Y. Articles for publication and communications regarding the editorial content of *Tappi* should be addressed to the Editor at the editorial office. Statements and opinions expressed in articles and editorials appearing in *Tappi* are those of the contributors, and the Technical Association of the Pulp and Paper Industry assumes no responsibility for them. Subscription: U. S. and possessions, $7.50; Canada, $8.25; Pan American Union, $9.00; Other Foreign, $10.00. Single copies to members of TAPPI, $0.75; Nonmembers, $1.00. Entered as second class matter January 27, 1949, at the Post Office at Easton, Pa. under the act of August 24, 1912. Copyright, 1949, by the Technical Association of the Pulp and Paper Industry. An index of the technical articles appearing in the magazine appears in the Industrial Arts Index and the Engineering Index.



Typical Liner Board Machine



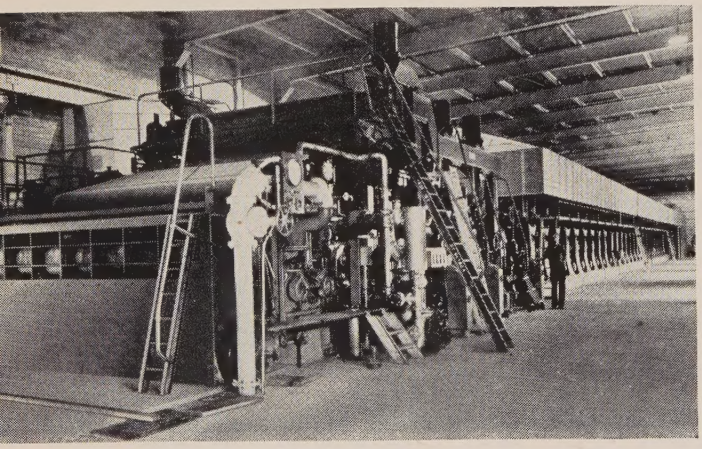
Typical Yankee Machine



Typical Newsprint Machine

SETTING THE PAC

for high-speed, large tonnag production of all kinds of Pap



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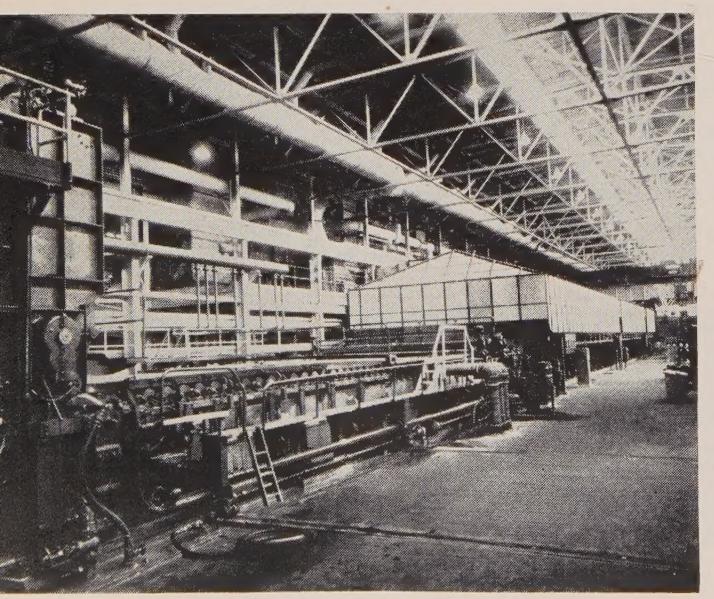
Puseyjones Machines set the pace for production. may be a large machine or a small one . . Fourdrinier Machine, a Cylinder Machine, a Yank Machine or a modification of any of these types. T performance of each Puseyjones Machine is backed a machine-building experience of more than 100 yea

Puseyjones is now erecting a Kraft Bag Paper Mach in Louisiana, a Specialty Paper Machine in Switzerla and a Stream Flow Cylinder Wet End in Swed Under construction is another Stream Flow Cylin Wet End for a prominent Board Mill in Ohio, an three-roll newsprint machine for India.

Puseyjones engineers will welcome the opportunity work with you in solving your paper-making proble If you want to know what's new in paper-mak equipment and what's on the boards for the futu write for the book, "A trip through the Puseyjo Plant." It's yours for the asking.



Typical Bag Paper Machine

THE PUSEY AND JONES CORPORATIO

Established 1848. Builders of Paper-Making Machine
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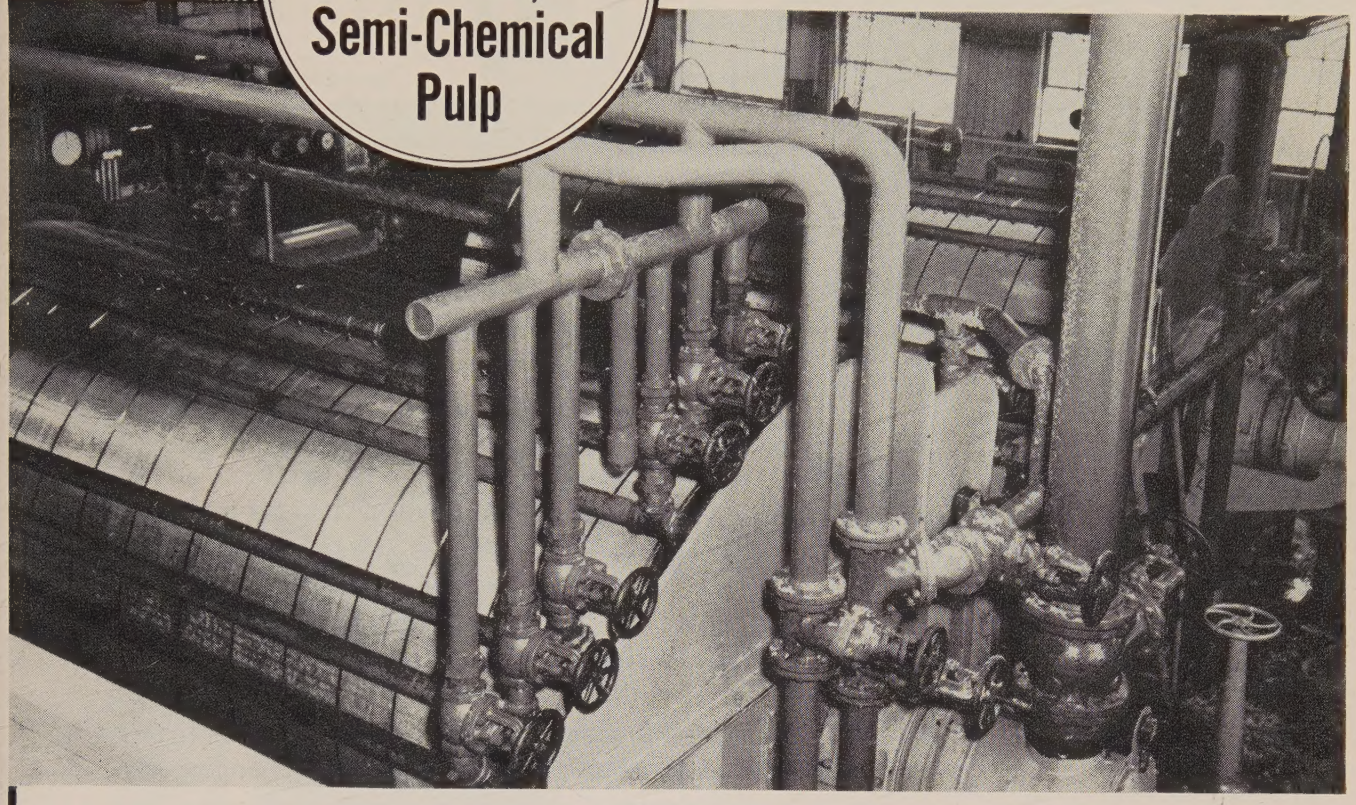
THE SIGN OF TRADE MARK SUPERIOR QUALITY

OLIVER "RINGVALVES"

for washing
Semi-Chemical Pulp



A book could be written about the wide use of the Oliver Ringvalve Filter for washing sulphate and sulphite stock . . . how its unique design and uniform sheet promote high washing efficiency . . . how its flexibility permits wide variations in washing methods.

Here's a "Ringvalve" installation at Sonoco Products Company, Hartsville, S. C. where the filters are operating on semi-chemical pulp and doing a fine job . . . more evidence of the versatility of the Oliver Ringvalve Washer! At present the two filters are operating as a 4-stage, series washing system. Later, when the tonnage is doubled, a third unit will be added and the system changed to 3-stage counter-current washing.

With such a fine record being made by the Oliver Ringvalve Washer in over 30 mills—a record of high washing efficiency, flexibility in operation, sustained overload or surge capacity—can you afford not to investigate fully its merits for your pulp washing requirements?

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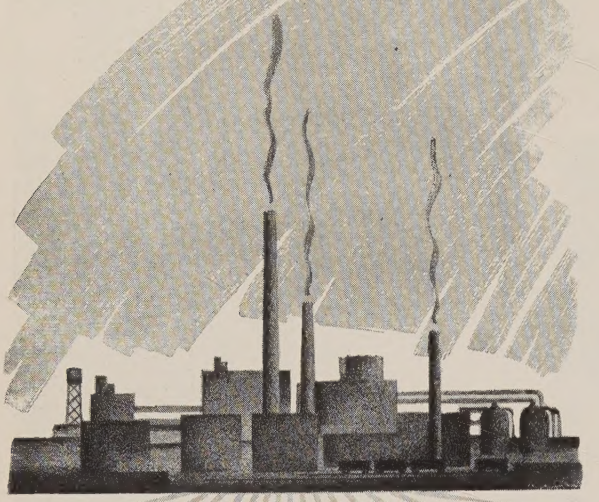
Chlorine production catalyzed by the paper industry



CHLORINE first began to be an important factor in the pulp and paper industry in the twentieth century. The basic procedure in pulp bleaching had already been established. As early as 1830 reference is made to its commercial use in Russia for bleaching straw and esparto. By 1847 chloride of lime had been substituted for chlorine water.

The rapid expansion of the pulp and paper industry coincided closely with the increase in the electrolytic manufacture of high quality chlorine. The cooperative research and experimentation of pulp and paper makers and chlorine producers were also potent factors in the development of superior bleaching processes. These led to the economical and large volume production of high quality papers. Hooker Electrochemical Company has been active in these developments, has contributed much to the techniques of pulp bleaching, and in the engineering "know how" that were so necessary to make these processes practical.

Having grown up with the pulp and paper industry, Hooker knows the importance of uniform high quality chemicals and continues to provide chlorine, caustic soda, and other Hooker pulp and paper chemicals that more than meet your standards for purity.

Hooker Technical Bulletins, some old and some new, are of particular value to newcomers in this industry. A request on your letterhead will bring you a list of those available.

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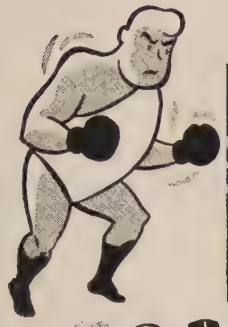
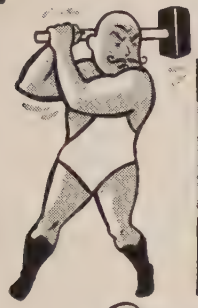
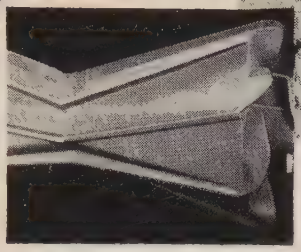


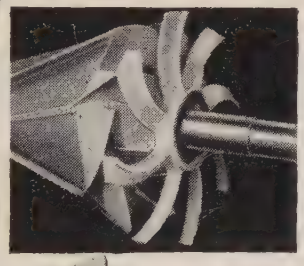
"I pound"

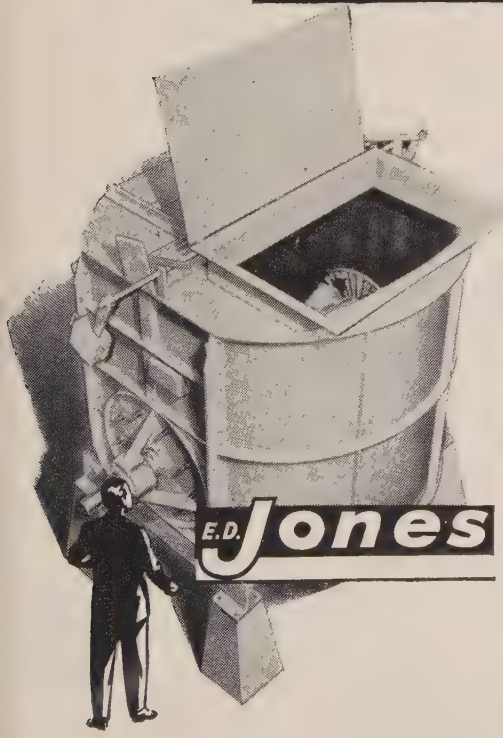


"I slam"



"I whirl"





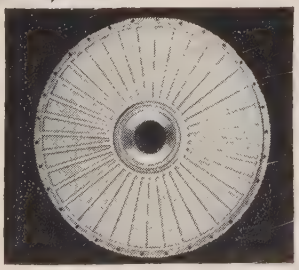
This photograph (taken with stroboscopic light) can give only a hint of the tremendous agitating force produced by the Pulp-Master. No mere swishing or swirling here — but pounding, slamming, whirling, grinding . . . **pulping power!**

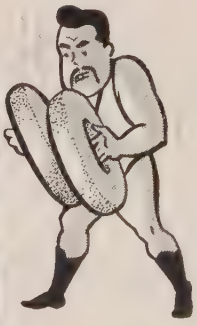
4-way action. Diagonal bars on the heavy rotor quickly break up whole charges, baled or loose. Cone shape of rotor forces stock against walls, where specially shaped impeller blades whirl and recirculate it. When pieces are sufficiently reduced they are rubbed between impellers and radial barred refining discs for thorough defiberization.

Complete disintegration of baled pulp, wastepaper, machine broke in 10 to 40 minutes. Efficient use of power and low maintenance cost make it extremely economical, too.

T-2

"I grind"





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WHISKERS
with . . . . . .

cut
MILL WASTE
with . . . . . .

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FLOTATION
SAVEALL

save | **FIBER, FUEL WATER, CHEMICALS**

solve | **STREAM PURIFICATION PROBLEMS**

Sveen Pedersen Flotation Saveall cuts mill waste more effectively than the conventional type savealls. Its flotation action recovers more fibers and fillers; water is clarified to such a high degree of purity that it can be extensively re-used in the system. Sveen Pedersen greatly reduces fresh water and fuel consumption, and virtually eliminates stream improvement problems.

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Shartle "HMS" extra-high-density centrifugal

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This particular pump is successfully handling stock of a consistency as high as 8%, 9% and 10%—in some instances 11%—and that's coming close to pumping actual paper.

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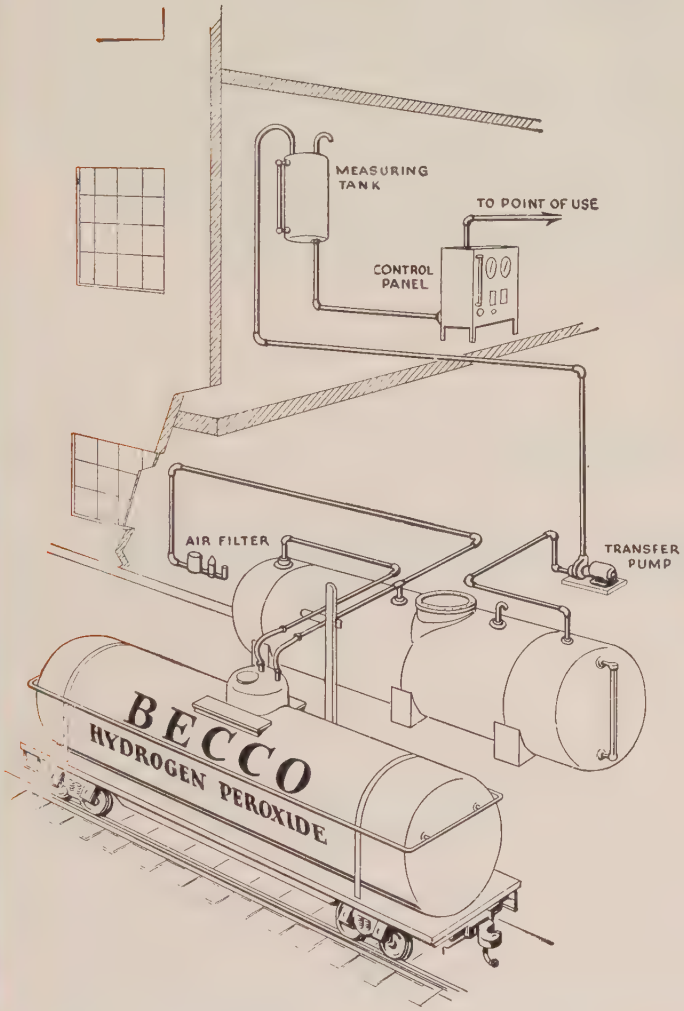

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EDITORIAL *Tappi* COMMENT

Merry Christmas

This issue of *Tappi* should reach most of its readers during the Yule Season. With this thought in mind the staff of *Tappi* wishes to extend the Season's Greetings to the members of the Association, the TAPPI local sections, the members of committees, the advertisers, and to all who will read this page.

The Annual Meeting

It will soon be February and Paper Week. The annual meeting will be held once again at the Commodore Hotel in New York City (Feb. 20–23, 1950). In the November issue the dates for this meeting were announced, and creatures of habit that we are, we stated that this meeting will be held in February 1949. Not only did we say so but proofreaders and everyone else involved concurred. We must write 1950 fifty times so that this mistake will not be repeated. However, it will require considerable will power to indicate 1950 on the first letters written in January.

The Spring and Fall Meetings—1949

The fading year has been an eventful one for the Technical Association. When we consider *Tappi* we may say that it has been a colorful year, the rainbow of the magazine covers attesting to this. The magazine, however, has been a reflection of the Association activities both national and regional and shall we say sectional.

Aside from the annual meeting four outstanding national conventions were held. In the spring the Coating Conference convened at Grand Rapids, in September a great fall meeting of the "old-time" type was held at Portland, Ore. At the end of October the Fourth Engineering Conference of the Pulp and Paper Industry went on to acclaimed success at Boston and in November the Fibrous Agricultural Residues Conference at Terre Haute continued its unusually fine record as an association within the Technical Association.

Fibrous Agricultural Residues

The Terre Haute convention, although one of the smallest of the TAPPI meetings calls for special comment, partly because it was the most recent of the four mentioned but, more important, to clarify the aforementioned term "an association within TAPPI." This convention serves a definite branch of the industry—the manufacturers of paper and paperboard products from straw. Its scope is nearly as broad as the Association itself. It is attended by individuals representing all phases of manufacturing responsibility and thereby benefits by an integration of interests that are unmatched by any other branch of the industry. Because of this integration and the enthusiastic support by the strawboard companies there has been steady progress in the literal sense. Since the first of these meetings were held at Peoria the program of work has hewed to a definite line of continuity that has permitted the Conference and the Fibrous Agricultural Residues Committee that sponsors it to make a real contribution to the improvement of the art of making paper products from straw.

With the continued fine cooperation of the strawboard companies and Northern Regional Research Laboratory at Peoria the results of the Committee's efforts should eventually be profitable to all concerned. So many individuals are responsible for this progress we will avoid mentioning any names in this tribute.

Committee Secretaries

It has been said that the best committee is composed of one interested individual. This is somewhat of a misconception and rather indicates that many successful committees attribute their success to the effort of one individual, usually the chairman. When a committee is able to meet, it is obvious that most of its members are willing to do their part. It is during the intervals between meetings that snags are encountered—when letters are written and frequently unanswered—and differences of opinion create stalemates that slow up the committees progress.

Several committees, notably those in the recently reorganized Engineering Division, have discovered the function and benefit of the use of a catalyzing agent in the person of a committee secretary. In the case of the Engineering Division committees the chairman is usually a busy and exceptionally able engineer employed by a paper manufacturer or a consulting engineering firm who can supply the necessary leadership in approaching industry problems but who is not able to devote the necessary time and clerical effort to obtain the cooperation of other engineers who, like himself, are willing to help but find it difficult to do so. The committee secretary is an individual who is enthusiastically interested in the progress of the work within the scope of a committee and who, in the course of his routine company duties, is able to supply the link of coordination. He usually has the necessary clerical facilities available and has occasion to get around to many of the mills represented on the committee. The immediate objectives of a committee can, in this way, be attained. All committeemen are provided with an opportunity to take a more active part in the work. This new *modus operandi* is recommended to all committees for consideration when they meet in February. It is really working in the Engineering Division and accounts for the unusual success of the annual engineering conferences.

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Supply-Demand Data on Chief Nonfibrous Raw Materials Used in the Pulp and Paper Industry

II. Inorganic Papermaking Chemicals

RUTH E. SHALLCROSS

CONTINUING THE article on the supply-demand data on the chemical nonfibrous raw materials used in the manufacture of pulp which appeared in *Tappi* 32, No. 11: 14A–32A (1949), a discussion of the chief chemical raw materials used in the manufacture of paper—whether book paper, paperboard, building paper and board, or other type—is in order. In the making of paper, a great many inorganic and organic nonfibrous materials are used. Chief among the inorganic group are the principal fillers and coating materials—such as clay, talc, titanium dioxide, and zinc sulphide pigments (including lithopone), calcium carbonate, calcium sulphate, barium sulphate, and satin white. Other inorganic materials are used in papermaking—the two chief ones being sodium silicate and aluminum sulphate, or papermakers' alum.

In the article on the consumption of pulp-making chemicals, mention was made of the scarcity of statistical data on the quantities used by the pulp and paper industry. The present survey shows that the data on the inorganic papermaking chemicals are infinitely more scarce than are those on pulp-making chemicals. There are a few exceptions to this statement, clay being the most conspicuous one. The Bureau of Mines does an excellent reporting job on the production-consumption picture of this important papermaking ingredient.

CLAY

Of the various types of clay produced, the paper industry is interested chiefly in kaolin or China clay—an aluminum silicate. China clay is a term usually applied only to imported clays and kaolin to the domestically produced material, but the terms are used interchangeably in the south. The physical properties of the two are very similar—both having many variations in grades. The paper industry uses kaolin or China clay both as a filler and as a coating agent. The use as a filler exceeds the use as a coating, as the consumption pattern in Table I shows. However, the use of clay in paper has not increased to anything like the same extent that the coating use of clay has which now is about to catch up with the filler use (see Fig. 1). In the twenties less than 3% of the total supply of clay was used for coating, whereas 36 to 40% went for paper filler. In 1947, only 33% went for fillers and 21% for coating.

The paper industry cannot use some of the other clays available such as ball clay or stoneware clay. It has been known to use small amounts of bentonite and fuller's earth but not enough to tabulate statistically in the data compiled by the Bureau of Mines. Kaolin, or China clay, constitutes only about 5% of the total amount of all clays produced for use or sale in this country. But of that type of clay, the paper industry is by far the largest consumer, its usage ranging from 55 to 60% of the total United States consumption. The rubber industry since 1945 has been paper's nearest competitor for kaolin, taking 12% of the total consumption. The clay consumption in rubber varies greatly depending upon the availability of carbon black, the ability to use a filler that does not give the extreme strength of the black, the need for a white filler, and the price. This variation is reflected in the table on the use-breakdown of kaolin. Refractories have been the third largest user of kaolin since 1945, taking 10% of the supply. But refractories take much more fireclay than kaolin, although they use kaolin in furnace construction and in specialty fire bricks. Pottery has usually been paper's nearest competitor (taking 8% of the total quantity consumed), although it draws more heavily upon the ball clay or stoneware clay than upon kaolin for its raw materials. Table I shows the breakdown by industry of the total quantity of kaolin "sold or used by producers."

At the turn of the century, when the paper industry began to use wood pulp in large quantities, kaolin became one of the essential raw materials as a filler. Its use as a coating material grew in importance, particularly after paper machine coating of book papers came into the picture. Imported clays were used for coating purposes up to World War I, after

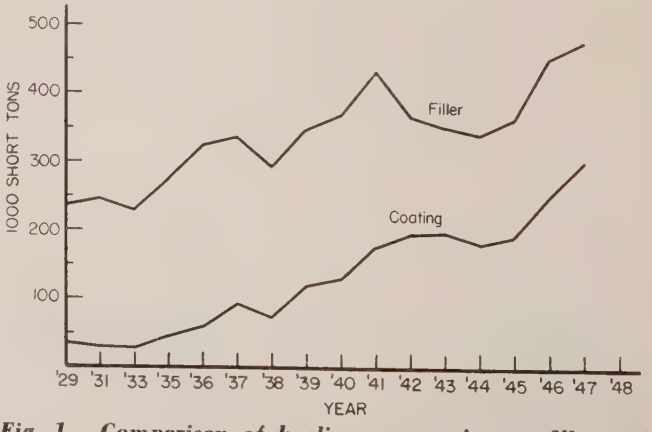

Fig. 1. Comparison of kaolin consumption as filler and coating agent

RUTH E. SHALLCROSS, Research Associate, The Institute of Paper Chemistry, Appleton, Wis.

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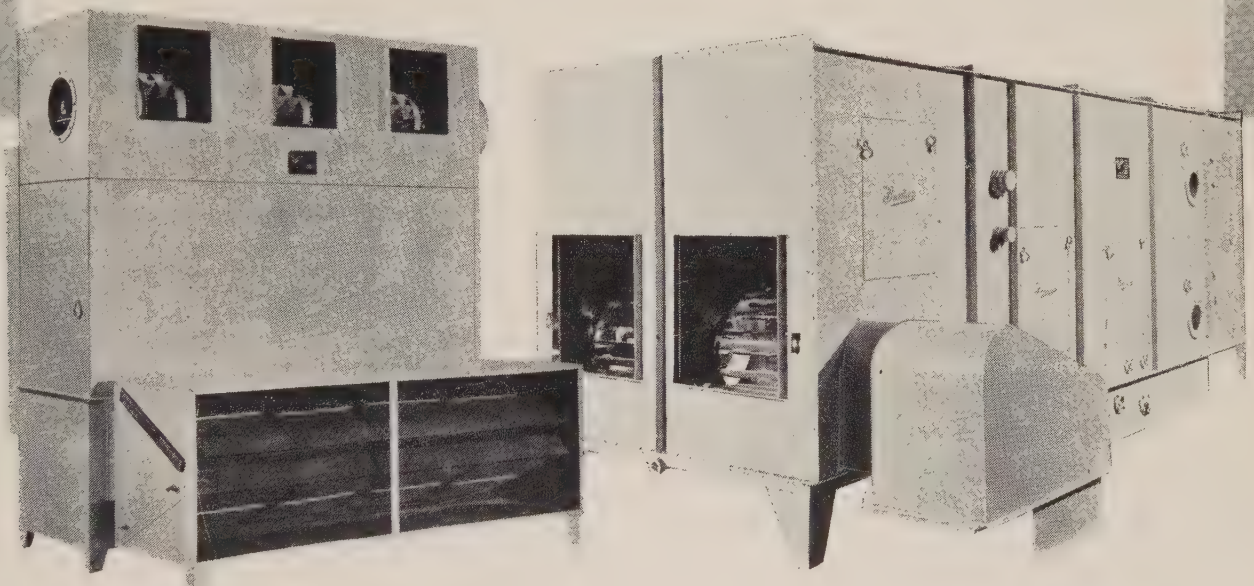

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which high-grade coating clay was produced from the Georgia deposits.

Clay is not a scarce natural resource. The large known deposits of good quality clay, conveniently located near the large industrial markets, however, are not plentiful. Before the war the United Kingdom produced the most China clay, the United States the second largest amount, Czechoslovakia third, and Germany fourth. Undoubtedly other deposits will be utilized when there is enough demand for clay and where the combination of risk capital and labor can be utilized profitably to develop them. Great Britain has used its fine grade Cornwall and Devon clay as one of its most important raw material exports. Coal has been its most important export, and clay has been second only to coal. Before World War I, the British supplied about $^2/_3$ of the total United States demand for China clay. However, during that war, the exorbitant ocean freight rates caused domestic production to increase. Production was mechanized and the quality of the clay improved to such an extent that, when the war was over, many a clay consumer found Georgia clay preferable to English clay.

During World War II, the British followed a policy of industry concentration in which the large clay mines were allowed to produce and the rest were closed. Following the war it has been difficult to open the closed mines so that only by failing to meet the domestic demand have the British been able to export clay to the United States, and then not up to prewar levels. Clay is still mined in England by antiquated equipment and methods. Recognizing this, a British committee, during the latter part of the war period, came to this country to study American production methods. Lack of capital, however, has prevented putting them into widespread practice. Thus, the British have lost considerable exchange credit for the materials greatly needed from the United States.

Statistically, the picture is quickly grasped as to the status of British imports of China clay. The ratio of imports to U. S. consumption dropped from 48.1% in 1923 to 35% in 1929; 19.4% in 1935; 16.7% in 1937; 12.8% in 1939; and to about 5% during the last war. That is, from an import tonnage of 312,000 tons in 1923 and nearly 400,000 in 1926,

Table I. United States Kaolin

Quantity Sold or Used by Producers, by Uses, 4-Year Averages, 1921–28, and Specified Years, 1929–45

Period or year	Paper: Filler	Paper: Coating	Total	Pottery[a]	Rubber	Refractories	Cement	Paints	Linoleum and oilcloth	All other	Grand total
					Quantity (1000 Short Tons)						
Annual average											
1921–24[b]	99	7	106	87	14	3	29[c]	14	7	15	275
1925–28	170	13	183	90	30	28	53	16	11	26	437
Annual											
1929	235	33	268	95	34	32	43	17	15	14	518
1931	245	28	273	48	32	32	31	11	7	9	443
1933	229	27	256	41	50	22	18	10	5	9	411
1935	274	45	319	53	59	32	28	10	6	17	524
1936	323	57	380	66	73	50	26	14	2	28	639
1937	335	91	426	68	86	77	33	7	6	29	732
1938	291	71	362	52	71	41	34	8	5	22	595
1939	346	117	463	78	90	57	42	10	6	35	781
1940	367	127	494	91	93	70	40	10	6	29	833
1941	431	174	605	126	127	123	43	14	10	40	1088
1942	364	193	557	98	51	160	12	17	6	46	947
1943	350	195	545	96	51	148	13	17	4	55	929
1944	338	179	517	94	60	104	15	18	4	62	873
1945	362	188	550	84	110	90	14	22	14	56	940
1946	449	248	697	126	162	133	48	22	13	121	1322
1947	474	302	776	120	166	142	...	...	...	...	1425
1948	...	...	872	146	177	146	...	...	...	...	1569
					Percentage of Total Quantity						
Annual average											
1921–24	35.8	2.7	38.5	30.9	5.1	1.2	10.4	5.2	2.5	6.2	100.0
1925–28	38.9	2.9	41.8	20.6	6.8	6.5	12.1	3.7	2.6	5.9	100.0
Annual											
1929	45.4	6.4	51.8	18.3	6.6	6.2	8.2	3.2	2.8	2.9	100.0
1931	55.3	6.4	61.7	10.8	7.2	7.2	7.0	2.4	1.5	2.2	100.0
1933	55.6	6.6	62.2	9.9	12.1	5.4	4.3	2.5	1.2	2.4	100.0
1935	52.3	8.6	60.9	10.2	11.2	6.2	5.3	2.0	1.2	3.0	100.0
1936	50.6	8.9	59.5	10.4	11.3	7.9	4.1	2.1	0.3	4.4	100.0
1937	45.8	12.4	58.2	9.3	11.7	10.5	4.5	1.0	0.9	3.9	100.0
1938	49.0	11.9	60.9	8.7	11.9	6.9	5.8	1.3	0.8	3.7	100.0
1939	44.3	15.0	59.3	10.0	11.6	7.3	5.4	1.2	0.8	4.4	100.0
1940	44.0	15.3	59.3	10.9	11.1	8.5	4.8	1.2	0.7	3.5	100.0
1941	39.6	16.0	55.6	11.6	11.7	11.4	3.9	1.3	0.9	3.6	100.0
1942	38.5	20.4	58.9	10.4	5.4	16.8	1.3	1.8	0.7	4.7	100.0
1943	37.7	21.0	58.7	10.3	5.5	15.8	1.4	1.8	0.5	6.0	100.0
1944	38.7	20.5	59.2	10.7	6.8	11.9	1.8	2.0	0.5	7.1	100.0
1945	38.5	20.0	58.5	8.9	11.7	9.6	1.5	2.3	1.5	6.0	100.0
1946	33.9	18.8	52.7	8.0	12.0	10.0	...	...	...	...	100.0
1947	33.2	21.2	54.4	8.0	12.0	10.0	...	...	...	...	100.0
1948	...	...	55.8	9.3	11.3	9.3	...	...	...	...	100.0

[a] Includes white-bodied floor and wall tiles.
[b] 1921 was the first year uses were reported separately.
[c] Estimated.

Source: 1921–23, U. S. Geological Survey; 1924–45, U. S. Bureau of Mines, reprinted by U. S. Tariff Commission (14, pp. 20–21). 1946 data from Minerals Yearbook, 1946; 1947 data from Mineral Market Report No. 1618.

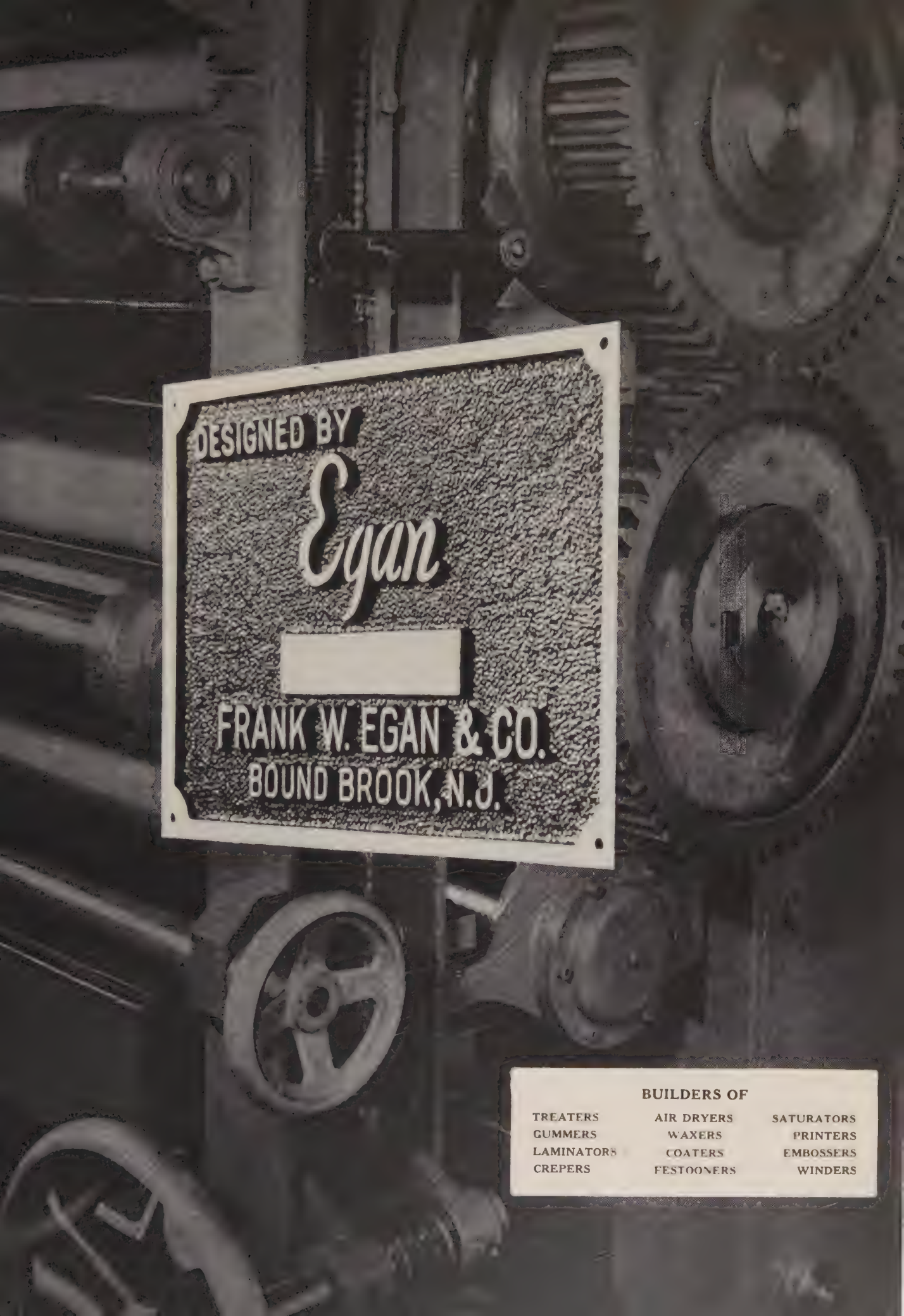

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Table III. Delivered Selling Price of English and Domestic Paper Clays

Consuming center	Filler clay				Coating clay			
	English		Domestic		English		Domestic	
	1939	1947	1939	1947	1939	1947	1939	1947
Holyoke, Mass.	$15.21	$18.47	$15.04	$18.24	$18.96	$23.17	$19.04	$23.24
Niagara Falls, N. Y.	16.01	19.43	15.28	18.48	19.76	24.13	19.28	23.48
Ridgefield, N. J.	13.91	16.91	14.60	17.80	17.66	21.61	18.60	22.80
Philadelphia, Pa.	12.91	15.71	14.38	17.58	16.66	20.41	18.38	22.58
Chillicothe, Ohio	17.41	21.11	13.83	17.00	21.16	25.81	17.83	22.00
Indianapolis, Ind.	18.41	22.23	13.58	16.70	22.16	26.93	17.58	21.70
Kalamazoo, Mich.	18.41	22.23	14.75	17.95	22.16	26.93	18.75	22.95
Niagara, Wis.	21.51	25.33	16.09	19.29	25.26	30.03	20.09	24.29
Cloquet, Minn.	21.41	25.23	16.64	19.84	25.16	29.93	20.64	24.84

SOURCE: U. S. Tariff Commission Report (14, p. 72).

it dropped to a low of 115,000 in 1939, to 85,000 in 1941, and to 46,000 tons in 1944; it increased to 57,000 in 1945 and to 90,000 in 1946; it declined again to 83,000 tons in 1947, but rose to 100,000 in 1948. Before World War I, the high tariff of $2.50 a ton (Act of 1909) did not prevent the American paper producers from buying it. But the strides made by the American clay producers during that war to improve quality made the freight rate of $1.25 per ton quite a deterrent for some of the paper mills some distance from the eastern seaboard.

Exports of kaolin have been so minor that the United States Department of Commerce did not classify them separately until 1945. They have been increasing slowly, 12,000 tons being reported in 1945, 15,000 in 1946, and 18,700 in 1947.

Most of the book and coated paper mills are located in the northern part of the United States, some 500 to 1200 miles from the chief source of supply in Georgia. Because transportation comprises one half or more of the delivered price paid by the consuming mills and because the domestic rail rates differ for domestic and imported material, those mills on the eastern seaboard find it more advantageous to buy imported clay. Inasmuch as the quality of the domestic clays has now been proved, the competitive advantage rests with location and is determined largely by transportation rates. Table II shows the price relationships.

Price to the paper mills, in particular consuming centers, shows where and why the British imports are still in the U. S. consumption picture. Unless freight rates change, it is evident from Table III that the domestic product has an advantage in paper-manufacturing localities west of Pennsylvania. The situation, however, changes from time to time and should be periodically surveyed.

Table II. Paper Clay Prices

	English f.o.b. vessel (Fowey, Eng.)	Ocean charge	Duty	Selling price, port of entry	Domestic clay f.o.b. mines (Ga.)
Filler clay					
1939	$5.50	$3.20	$1.56	$12.01	$8.00
1947	6.25	5.07	1.56	14.63	10.00
Medium coating clay					
1939	8.00	3.20	1.56	15.76	12.00
1947	9.70	5.07	1.56	19.33	15.00

SOURCE: Adapted from table in U. S. Tariff Commission Report (14, pp. 70-71).

TALC

Talc, a hydrated magnesium silicate, is a competitor of sorts with clay as a filler in some kinds of paper. Even though the price per ton of the fibrous talcs has usually run considerably higher than clay, a certain tonnage has been consumed by the paper mills. For a small number of special papers, the improved sheet formation gained by the use of talc is sufficient to justify its use. This has been particularly true in the past of highly illustrated papers made by firms which have worked out special furnishes in which talc is the agent desired. If particular customers are pleased with the contracted paper, a mill is loathe to change the furnish which produced it. This accounts for the fact that, for the last 15 years, the quantity of talc consumed by the mills has stayed approximately the same in comparison with the consumption of clay, which has increased with the rise in total paper production (see Fig. 2).

Many of the older mills still using talc do not find the price enough higher to make much difference economically, particularly when it takes less talc than clay to accomplish the same functions, as talc has better retention qualities. However, newer mills which have accounted for the greater part of the rise in paper production during the last 15 years have introduced savealls for clay and fiber which give clay about the same advantage as talc in amounts necessary for similar papers.

The decreased use of talc (measured in tons per ton of total paper) has not been due to a scarcity of the product itself. Its production has increased, but other industries within the last 10 years have taken more than has the paper industry. Statistics on the supply of talc are difficult to obtain with the preciseness desired, inasmuch as, along with it, the Bureau of Mines

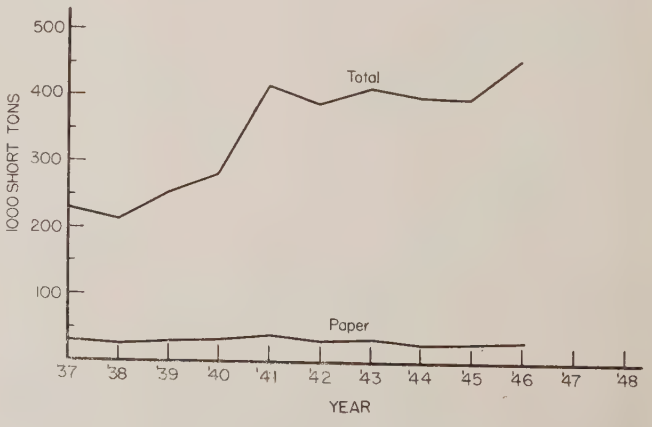

Fig. 2. Comparison of total consumption of talc with its use by the paper industry

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Table IV. Domestic Sales of Talc, Pyrophyllite and Ground Soapstone by Industrial Use (1000 Short Tons)

Industry	1937 Tons	%	1938 Tons	%	1939 Tons	%	1940 Tons	%	1941 Tons	%	1942 Tons	%	1943 Tons	%	1944 Tons	%	1945 Tons	%	1946 Tons	%	1947 Tons	%
Paint	60	26	54	25	68	27	68	24	120	29	126	32	129	31	111	28	104	26	104	23	112	22
Ceramics	30	13	30	14	38	15	49	18	79	19	48	13	48	12	32	8	38	10	62	14	95	18
Rubber	27	12	25	12	31	12	28	10	58	14	40	10	49	12	52	13	64	16	66	14	72	14
Roofing	24	10	28	13	31	12	34	12	41	10	49	13	48	12	46	11	47	12	55	12	63	12
Insecticides	(tabulated in other)								10	2	16	4	24	6	21	5	37	9	65	14	67	13
Paper	32	14	27	13	30	12	32	11	38	9	30	8	34	8	27	7	28	7	32	7	32	6
Toilet prepns.	4	2	6	3	10	4	9	3	21	5	19	5	18	4	16	4	21	5	17	4	13	3
Other	53	23	43	20	46	18	61	22	49	12	60	15	63	15	94	24	59	15	56	12	62	2
Total	230	100	213	100	254	100	281	100	416	100	388	100	413	100	399	100	398	100	457	100	516	100

SOURCE: Minerals Yearbook for 1937-46.

tabulates pyrophyllite—a hydrous aluminum silicate of no interest to papermakers—and ground soapstone, or asbestine, which is used as a paper filler but not to the same extent as talc. If import-export data are considered, the supply picture is further confused by the inclusion of French chalk. Imports and exports can be left out of the supply picture because they just about cancel out, although during the war the amount imported was much less than the amount exported. In 1946, there were 16,000 tons exported and 18,000 tons imported. French chalk is unidentified in the import total.

Because no other data are available on consumption, the small amounts of pyrophyllite will have to be discounted and present data used. The largest proportion of sales in 1946 of the three materials (talc, pyrophyllite, and ground soapstone) went to five industries: paint, rubber, roofing, ceramics, and insecticides, which took 77% of the total supply. The paper industry consumed nearly as much of the supply as insecticides and, when added to the total of the other five industries, makes up 84% of the total consumption. In 1931 when the ceramics, roofing, and rubber industries consumed 23% of the total consumption (insecticides at that time did not use enough of the supply to be tabulated separately), the paper industry took 16%, ranking second only to the paint industry, a position it lost in 1938 when ceramics consumed more tonnage than the paper industry. By 1941, the rubber industry was second in rank to the paint industry, a position it still holds. Table IV gives consumption (defined as domestic sales) and its distribution among the various industries.

Other Mineral Fillers and Coating Agents

Other fillers and coating agents, either natural minerals or manufactured mineral products, include: titanium dioxide and zinc pigments (including lithopone), calcium carbonate or chalk, calcium sulphate or gypsum, barium sulphate or blanc fixe, and satin white.

Titanium dioxide and zinc sulphide pigments, including lithopone, are preferable to other fillers and coating agents in imparting opacity and at the same time giving added brightness to some types of paper. Consequently, when these characteristics are especially desirable, their higher prices are not a deterrent to use.

The supply of *titanium dioxide*—the most desirable of all white pigments from the standpoint of opacity—has been increasing since the war, but is still not up to the demand which has increased also. Supply data are not published by the Bureau of Mines on titanium products because they would divulge confidential company information, a situation which assumes some elements of monopoly practices in the industry. Antitrust charges have been pressed by the U. S. Department of Justice, although the U. S. Supreme Court has not yet rendered a decision on the case. However, the case itself has disclosed some production data on titanium pigments which are reproduced in Table V.

Table V. Titanium Pigments (Data in Short Tons)

Year	Production	Possible paper industry use (estd.)
1920	100	?
1941	128,000	13,000
1943	110,000	11,000
1946 (estd.)	140,000	14,000

SOURCE: U. S. Bureau of Mines, Minerals Yearbook, 1946: 1186.

In 1946 the paint, varnish, and lacquer industry consumed 75% of the total production; according to one of the leading manufacturers, 10% went into paper, 2% for floor coverings and rubber, 1.5% for welding rod coatings and textiles, and 8% for other uses (1946 Minerals Yearbook).

Ilmenite, from which titanium pigments are made, occurs in Florida, New York, New Jersey, North Carolina, Virginia, and Wyoming. The shortage in titanium pigments has not been the result of a shortage in the basic raw materials, although considerable amounts of ilmenite are imported yearly, nearly all of which come from India. During the war and in the postwar period titanium pigments were exported. Germany has always been a big supplier of titanium pigments to European manufacturers of paints, welding rods, flux, and paper. New uses were found for titanium as the result of wartime research in Germany which may help increase the demand in the United States and, unless the supplies increase, will influence its price.

Of all the *zinc pigments*, more data exist on *lithopone* than on the others. This is because there is only one chief manufacturer of zinc sulphide pigments, so that the data on its production will not be released by the Bureau of Mines. The use of lithopone went up during and directly after the war because titanium dioxide was in shorter supply. For some grades of bond, printing, and specialty papers, where titanium dioxide is not especially essential, it is more economical to use lithopone for opacity and brightness, even when both materials are equally available.

The chief industrial users of lithopone are: (1) paints, varnishes, and lacquers which take between

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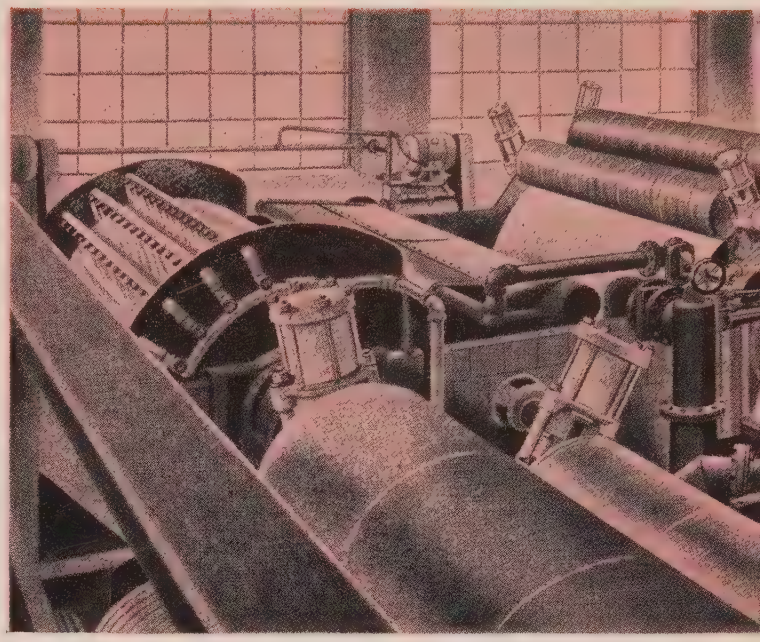

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75 and 80% of the total; (2) floor coverings and textiles which take 12 to 13% of the total. In the statistics available on lithopone, the amount used by paper is hidden in the term "other." However, the Bureau of Mines in correspondence has released data on this use as is shown in Table VI.

Table VI. Lithopone (Data in Short Tons)

Year	Supply [a]	Consumption by paper industry [b]	Supply, %
1935	159,486	679	0.4
1936	158,319	1629	1.0
1937	154,771	2145	1.4
1938	125,746	1352	1.1
1939	142,759	2407	1.7
1940	151,802	4678	3.1
1941	176,642	5559	3.2
1942	137,320	3423	2.5
1943	135,723	4043	3.0
1944	142,905	6488[c]	4.5
1945	136,161	3086[c]	2.2
1946	147,001	3011[c]	2.1
1947	165,024	4069[c]	2.4
1948	140,900		

[a] Shipments from Minerals Yearbook.
[b] From correspondence with H. M. Meyer, Metal Economics Branch, U. S. Bureau of Mines (Feb. 4, 1949).
[c] Minerals Yearbook, 1946: 701; 1947: 698.

Calcium carbonate is used in various forms as a filler and coating agent for book and cigarette papers. Some of the supply is imported as French chalk and tabulated by the Department of Commerce along with "talc, steatite, or soapstone." Total imports were 18,000 tons in 1946 but the amount of French chalk is unidentified, nor is industry distribution shown. However, it would appear in the distribution of total sales of "talc, pyrophyllite, and ground soapstone." Another obstacle in obtaining use data results from the fact that many of the alkaline pulp mills utilize the calcium carbonate from the causticizing operation, the amount of which is unreported. It is undoubtedly included in the lime sales to paper, but this fact does not help identify the industry's use of chalk itself. It is also difficult to estimate the total consumption of calcium carbonate, because of its other uses in the mill, such as the reaction with sulphurous acid gas to produce the filler, calcium sulphite. The amount of calcium carbonate used in paper has been estimated by Mispley (*5*) to be 75,000 tons a year.

Calcium sulphate, or gypsum (either as ground or calcined and known to the paper industry under a variety of terms such as terra alba, puritan filler, alabaster, pearl filler, calopone, etc.) is used in bonds, writing, and printing specialties to a certain extent (no data are available regarding such uses). The big tonnages of calcined gypsum used by paper manufacturers go into wallboard, sheathing paper, and laminating building board. Wallboard was not tabulated in the paper classification by the U. S. Bureau of Census until 1941, and laminating board is a new product which was marketed for the first time in 1942.

During the war, when imported salt cake was difficult to obtain, some kraft pulp mills used a mixture of calcined gypsum and salt as a wartime substitute, but no reports as to the amounts so produced are available. In any long-time trend of consumption of gypsum, however, such war uses should undoubtedly be discounted, anyway. In normal times salt cake is sometimes used with calcium chloride to produce what is known as crown filler, which is calcium sulphate crystals, but this use has never been reported by the mills. Some tonnage of crystallized calcium sulphate is produced from the action of sulphuric acid on phosphate rock to produce phosphoric acid and phosphate salts, and in other chemical industries in which sulphuric acid is used to release other acid radicals from their calcium salts. Inasmuch as the solubility of gypsum decreases its attractiveness in the fine papers, that tonnage is not great as compared with the amounts going into the boards. Some of this byproduct calcium sulphate is used in paper as a filler but no basis exists for estimating the amount so used.

Until such time as reporting on chemical consumption becomes a part of the routine in the periodic Census of Manufacturers, the tabulated use of gypsum in the paper and board industries is limited to the quantity which is employed in the manufacture of building papers and boards (see Table VII).

Barium sulphate, or blanc fixe, is used in photographic papers. A little has been used in high-priced specialty wallpapers, but the high price of the barium precludes its use to all but the papers which find its unique qualities of special importance, and its cost minor in comparison with the total selling price of the specialty paper.

Blanc fixe is produced synthetically by precipitation. It is also a byproduct of hydrogen peroxide manufacture but the amount so produced has not been tabu-

Table VII. Gypsum Products Sold or Used in the United States (Data in 1000 Short Tons)

Year	Supply of total calcined gypsum for building uses	Use for building papers and boards			Total	Percentage of supply
		Wallboard	Sheathing	Laminating		
1936	2074	243	...	...	243	11.7
1937	2519	241	...	...	241	9.6
1938	2462	270	...	...	270	11.0
1939	3114	303	5	...	308	9.9
1940	3580	380	87	...	467	13.2
1941	4288	612	179	...	791	18.5
1942	3322	873	375	56	1304	39.3
1943	2788	1028	238	211	1477	53.0
1944	2582	975	118	180	1273	49.4
1945	2682	1024	103	125	1252	46.7
1946	4532	1517	80	23	1620	35.8
1947	6085	2037	106	2	2145	35.2
1948	7808	2580[a]	130	...	2710	34.7

[a] Includes laminated board.
SOURCE: U. S. Bureau of Mines, Minerals Yearbook 1937 through 1946.

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lated. The Bureau of Mines collects reports on the production of the synthetic type. Table VIII indicates the amount sold or used in the United States.

Table VIII

Year	*Synthetic barium sulphate sold or used in U. S. (short tons)*
1936	16,149
1937	28,250
1938	19,428
1939	18,653
1940	22,247
1941	29,352
1942	25,779
1943	24,606
1944	30,804
1945	30,822
1946	34,171
1947	27,353

SOURCE: Minerals Yearbook 1937 47.

The data on paper consumption have been estimated on the basis of the production of baryta-coated photographic paper to be between 1600 and 2000 tons annually. Other uses have been omitted on the assumption that the amount would be negligible.

Few data exist on the supply of or demand for satin white either as a filler or a coating agent. It is made from lime and alum and even if production data were reported to the Bureau of Mines it would undoubtedly leave out the amount made by some of the paper companies for their own use. Sales have dropped to very low levels in the postwar period, so that the item has become of minor importance in any listing of fillers or coating agents. With the quality of clay improved, it is debatable whether satin white will again be used to the same extent as before World War II, even when top quality papers are in demand by consumers.

SODIUM SILICATE (WATER GLASS)

Two other inorganic chemicals—sodium silicate and aluminum sulphate, or papermakers' alum—are widely used in the paper industry; these are neither coating agents nor fillers, nor are they actually sizing agents, although they aid in these functions in some way. The paper industry uses sodium silicate chiefly as an adhesive in the manufacture of corrugated, solid fiber- and wallboard. It is also used to a minor degree as a sizing agent, in the deinking of waste papers, as a water softener, as a hardening agent, as an adhesive for carton sealing, as an agent for prevention of slime, as a dispersing agent for clay, and as a neutralizing agent for acid in colorings. It has greaseproof and water- and fire-resistant qualities which make it valuable to the paper industry in the manufacture of various packaging papers, a use which grew considerably during the war.

There are 29 establishments which produce sodium silicate in greater quantities than are needed to supply the domestic demand. Consequently, some tonnage each year is exported; in 1946 this was 24,131 tons, with a valuation of over a million dollars. A very slight tonnage is imported; this has varied from less than 50 tons in 1938 to the high level of 330 tons in 1945, according to the Bureau of Census.

The Bureau of Census has included the production of sodium silicate in its "Facts for Industry" series M19A since 1941. The data represent total production, including material produced for sale and made and consumed in the producing plant. The data on an anhydrous basis are given in Table IX.

Table IX. Sodium Silicate (Data in Short Tons)

Year	*Anhydrous base*	*Anhydrous base converted to 40° basis*
1941	386,189	932,000
1942	322,506	768,000
1943	361,863	920,000[a]
1944	428,353	1,071,000[a]
1945	410,686	1,027,000[a]
1946	412,357	1,031,000[a]
1947	474,589	1,186,000[a]
1948	483,856	1,210,000[a]

[a] Obtained by multiplying anhydrous base by 2.5.
SOURCE.: U. S. Bureau of the Census, Facts for Industry Series M19A.

The supply of sodium silicate on a liquid 40° basis and the estimated demand by the paper industry are shown in Table X.

Table X. Supply and Demand for Sodium Silicate (1000 Short Tons)

Year	*Supply* [a]	*Estimated demand by paper* [b]	*Total used by paper, %*
1929	590	236	40
1931	664	266	40
1933	630	252	40
1935	578	284	48
1937	601	...	..
1939	657	340[c]	40
1941	932	445[c]	47.5
1943	920	350[c]	38
1947	1186	430 (estd.)	36
1948	1210		

[a] Data to 1941 from *Chemical Facts and Figures*, 1940: 76. Later data from Release on Sodium Silicate prepared by W. R. Koster, Office of Domestic Commerce, Department of Commerce.
[b] Estimated by *Chemical and Metallurgical Engineering* (2, p. 67).
[c] Estimated by E. N. Poor (7).

The Sodium Silicate Manufacturers Institute states that no official data on the consumption by industry of sodium silicate exist. Thus, the paper consumption estimates are from information in the hands of suppliers and are the only available data. It is hoped that, in later compilations for the Census of Manufacturers, consumption data on this chemical will be routine.

ALUMINUM SULPHATE

Aluminum sulphate (hydrated) or papermakers' alum is used with sizing agents, in water purification, as a mordant in dyeing, to increase retention of paper fillers, and for a number of other lesser purposes.

Aluminum sulphate, together with other aluminum salts, has competed with the production of aluminum for the raw material, bauxite. The high-grade ore has been scarce in this country and has been imported from Dutch Guiana in large quantities. At the Hearings before the United States Senate National Resources Economic Subcommittee, May, 1947, bauxite was given as one of the ores having less than 25 years of reserves in terms of consumption at the 1935–44 annual rate, despite the fact that, during the war, a domestic intermediate grade was successfully used. Because the war uses of aluminum multiplied, the demand for bauxite increased greatly. Irving W.

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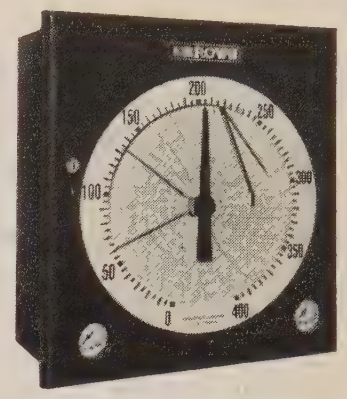

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Table XI. Aluminum Sulphate

Year	No. suppliers C.[a]	No. suppliers I.F.[a]	Production (in 1000 short tons) C.[a]	Production (in 1000 short tons) I.F.[a]	Production (in 1000 short tons) Total	Paper consumption Estimated	Paper consumption Percentage of supply
1935	22	7	346	18	364	117.5	32
1936	23	7	385	16	401	...	..
1937	24	7	412	15	427	...	..
1938	26	8	363	15	378	...	..
1939	27	9	415	24	439	140	32
1940	27	8	444	24	468	152	33
1941	28	9	525	35	560	183	33
1942	30	9	518	22	530	160	30
1943	28	5	559	16	575	143	25
1944	26	5	578	24	602	...	..
1945	27	6	557	30	567	150	26.5
1946	26	6	580	33	613	...	..
1947	..	..	606	24	630	240	38

[a] C. is commercial which also includes "municipal." I.F. is iron-free.

SOURCE: Data on number of suppliers and production from U. S. Bureau of Mines, Minerals Yearbook, 1936 through 1946; 1947 data from correspondence with Metal Economics Branch, U. S. Bureau of Mines. Paper consumption estimated: 1935—*Chemical and Metallurgical Engineering* (*2*); 1940, 1941, 1942, 1943 by E. N. Poor (*7*); 1945 estimated by R. G. Mispley (*5*); 1947 estimated by one of the leading suppliers.

Wilson, Vice-President and Director of Aluminum Company of America, has stated that, during the war, 70% of the output of the aluminum industry went into military aircraft alone. The chief deposit of bauxite in the United States is in Arkansas. Most of the production is not as iron-free as the paper manufacturers would like to have it, but increasing the productive capacity of iron-free alum, although mechanically and chemically feasible, is not economically feasible at the present time, according to Gee, et al. (*3*). Table XI shows the production of commercial and iron-free grades of aluminum sulphate as reported by the United States Bureau of Mines.

It is obvious from Table XI that the iron-free alum production is not sufficient to meet the entire needs of the paper industry and that much of its consumption is of the commercial grade. Accurate consumption statistics by reporting mills are greatly needed in this field of inquiry, as for any other chemicals used by the paper industry.

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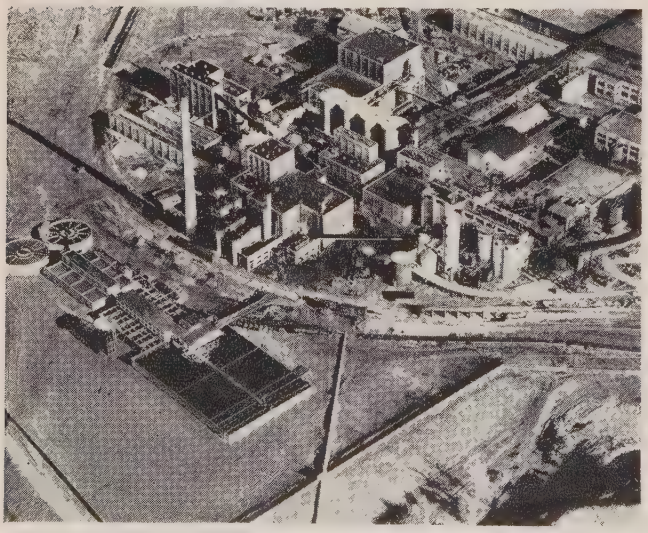
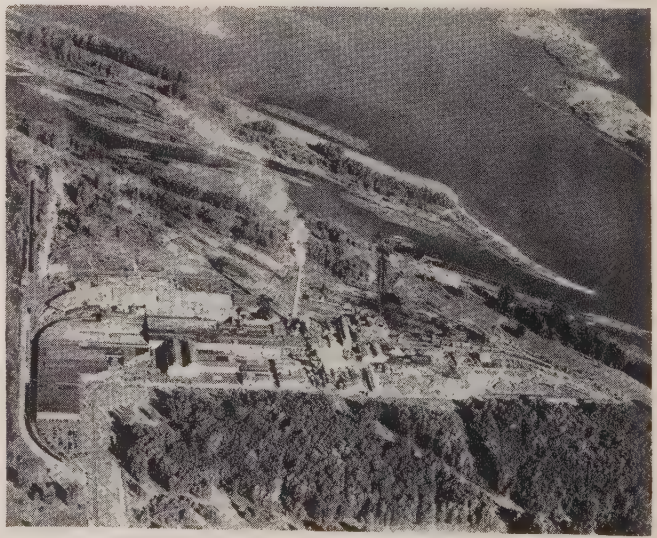
Acknowledgement: The author is indebted to her colleagues at the Institute for advice and criticisms.



Air view of the Weyerhaeuser Timber Co. mills at Longview, Wash.



Aerial view of the Longview Fibre Co. at Longview, Wash. taken in 1948

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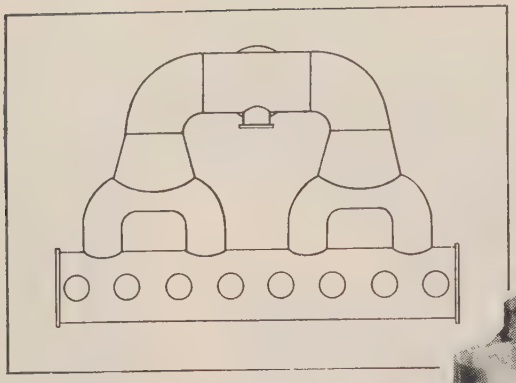

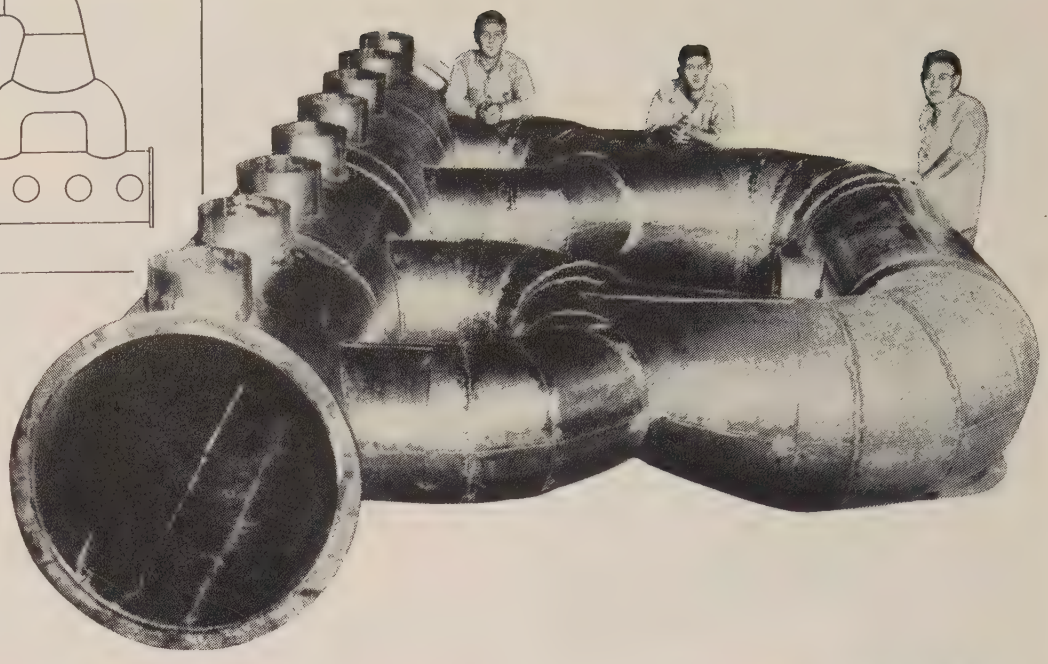

Header assembly for connecting paper machine fan pump to primary header in a large Southern paper mill. Ducts are 30" in diameter at widest points, and the assembly is more than 200" in overall length.

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Pay to the order of YOU
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Pay to the order of YOU
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$$$ PERFORMANCE
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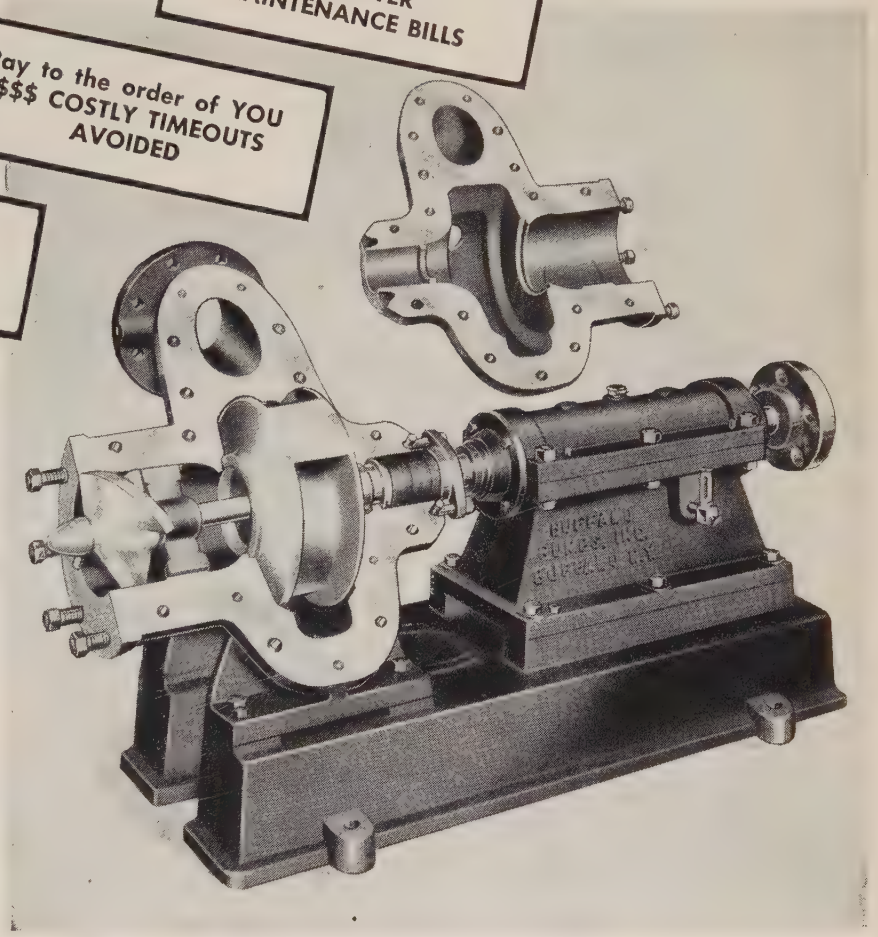
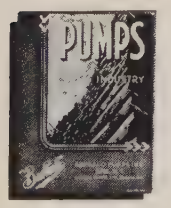


You get these "bonuses," first of all, through "Buffalo" high-efficiency impeller and casing design—high efficiencies which do not depend on close-running tolerances (which could cause extra wear, "wedging," and decrease in efficiency).

You get a big "bonus" in the over-all rugged construction of "Buffalo" Pumps. The special Non-Clogging "Buffalo" Impellers save many a maintenance dollar. Extra-heavy shafts, bearings and pump stands are built to take years of shock and punishment.

And best of all, you get a "bonus" in selection—the pump DESIGNED for your operation. The "Buffalo" line includes pumps for high heads, lumpy liquids, corrosive stocks, a wide range of chemicals—any condition you can name. All were designed in coordination with paper men, and have proven themselves in all kinds of installations.

Much appreciated by maintenance men, "Buffalo" Diagonally Split-Shell Stock Pumps have easily removable shells for quick inspection of all parts without touching discharge piping. Bearing also has removable upper casing.



WRITE for Bulletin 953-F—pick the durable "Buffalo" Pump designed for *your* stock, *your* consistency, *your* conditions!

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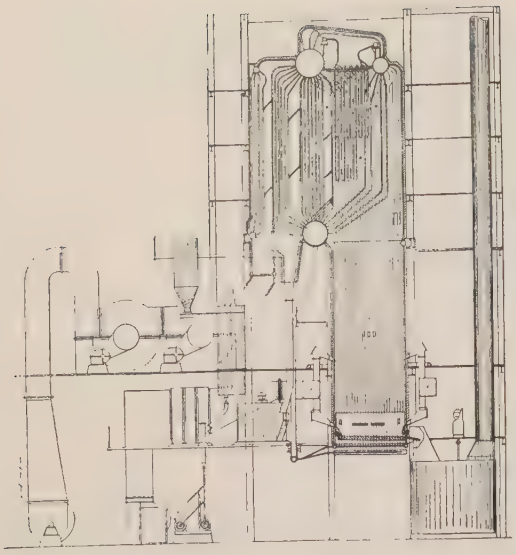
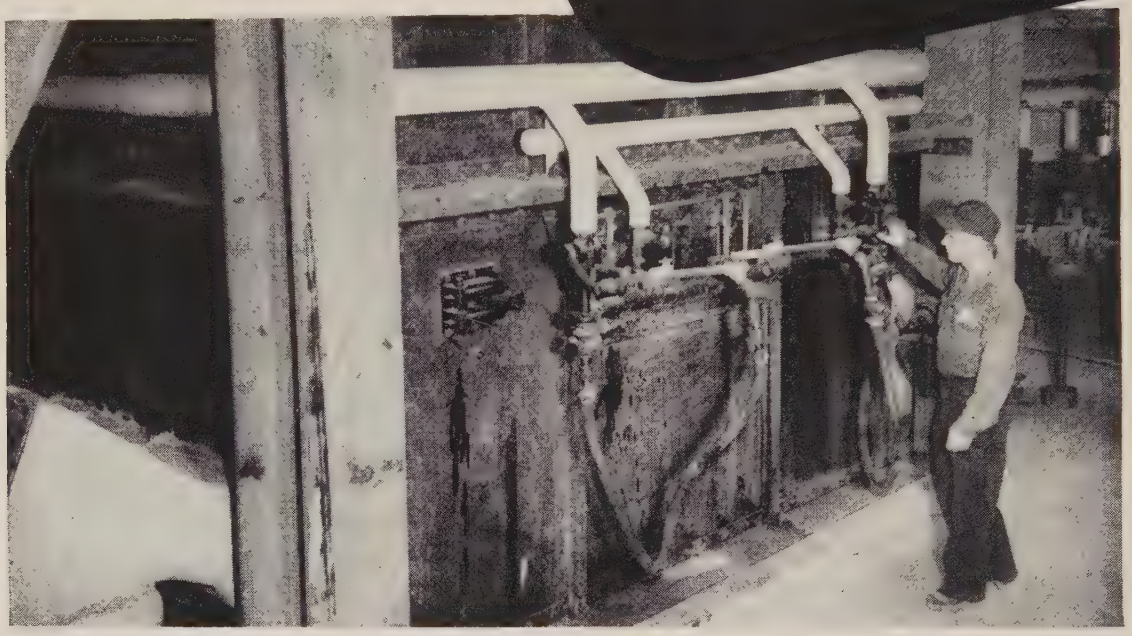


New Weyerhaeuser Mill uses C-E Recovery Unit



Firing level showing black liquor spray burners

The new Weyerhaeuser Mill at Springfield, Oregon is another important step toward the more complete utilization of the Pacific Coast timber crop. This mill uses the many cords per acre of good clean material recovered by the pre-logging and re-logging of Weyerhaeuser's 155,000-acre Calapooya Tree Farm. Additional raw material for this modern 150-ton per day kraft container board mill is provided by trims, edgings and slabs from the many sawmills in the area.

Chemical recovery for this notable new mill is accomplished by a C-E Recovery Unit. This unit, illustrated above, is designed to burn 464,000 pounds of black liquor solids per 24 hours and will produce steam at 570 psi and 675 F.

The reliability, economy and operating efficiency of the C-E Recovery Unit are well known. And, as you would expect, more and more mills have selected C-E for both new installations and expansion of existing ones. B-353

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"ALBONE" 50 Hydrogen Peroxide 50%

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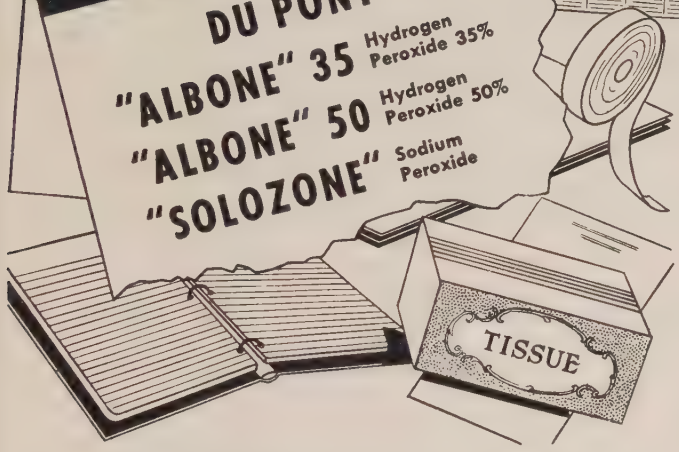
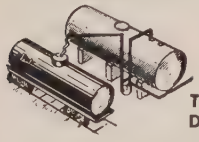
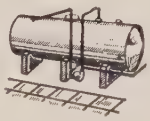


FOR THE GREATEST ECONOMY CONSIDER



Tank car Deliveries

Tank Storage at the mill



If you need 5,000 lbs. or more of "Albone" Hydrogen Peroxide per month, you'll find a storage tank installation economical. Du Pont engineers will help in the planning and facilities for bulk storage and handling.

MORE AND MORE mills are turning to peroxide bleached groundwood as the answer to the demand for low priced papers which must have brightness, bulk, opacity, absorbency and good printing properties. It is particularly useful for printing papers where high strength and long life are not essential. Substantial savings in manufacturing costs can be made because you start with a low cost fiber. Through peroxide bleaching it is possible to get improved opacity in a lighter weight sheet. For the production of many kinds of paper there may be a saving of 10% to 20% in fiber cost.

Peroxide bleached groundwood is now a regular item in a substantial number of integrated and non-integrated mills. Groundwood bleaching can be easily and economically installed in practically any mill.

Peroxide bleaching is not limited to groundwood. It can be adapted to soda, sulfite, semi-chemical pulps and for waste paper recovery.

Technical service and assistance in peroxide bleaching is available from the men who pioneered the development of groundwood bleaching. For more information about Du Pont peroxides and Du Pont bleaching processes, just fill in and mail the coupon below.

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BETTER THINGS FOR BETTER LIVING...THROUGH CHEMISTRY

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Please send me further information about Du Pont peroxide bleaching processes: (check application).

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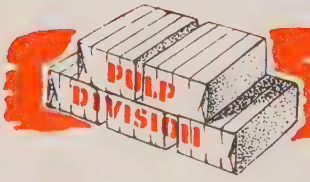
ETERNAL VIGILANCE

Weyerhaeuser is in the business of growing trees . . . looking ahead to a continuous, never-ending supply of timber.

That is the reason a forest fire today is seen as more than an immediate loss. It is recognized also as a threat to the future well being not only of Weyerhaeuser and the Pacific Northwest but of other communities, and even the nation at large.

And that is why in cooperation with others in industry and government, Weyerhaeuser helps maintain a vast network of look-out towers, forest patrols, radio and telephone communications, tank trucks and roads. Trained fire-fighters are always available. Forest fire prevention today and tomorrow is in the public interest for the present and the future.



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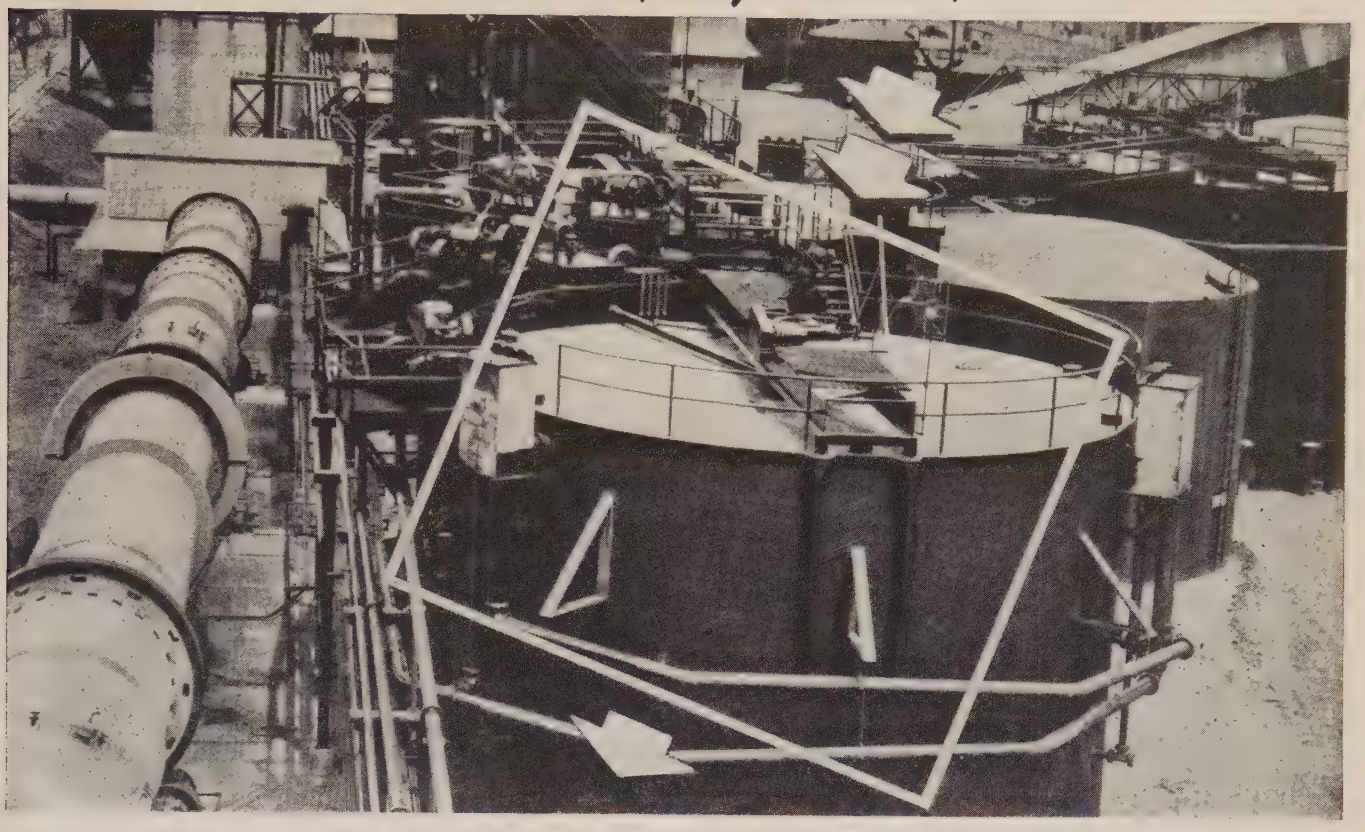
Is your Recausticizing System up to date?



how about the **LIME MUD WASHER...**

If you now use a single-stage of lime mud washing in your recausticizing plant, you probably aren't getting the most out of your equipment. Two stages of counter-current decantation washing of lime mud prior to filtration is now a standard design feature of the Dorr Continuous Recausticizing System. There's a good chance that you can incorporate this important advance into your present system . . . at a relatively small cost . . . *without providing additional thickening area.* Modification of the feed and overflow boxes, redesign of the middle tray, and an additional diaphragm pump are the only changes required.

Here's how this simple conversion will improve your entire recausticizing operation. Two-stage Dorr installations consistently reduce soda content of the filter feed to 1½%, yielding a filter cake feed to the kiln *containing one-half of one percent soda,* expressed as Na_2O. This means increased chemical recovery, improved kiln operation and longer life for kiln linings.

In addition, two-stage mud washers increase the flexibility of the system. First, in an emergency, the top two compartments can serve as a White Liquor Clarifier, the bottom two providing a single stage of mud washing. Second, if the filter station is down, the lime mud is sufficiently low in soda content to be fed directly to the kiln.

In the development of the Dorr Continuous Recausticizing System, our engineers have accumulated a wealth of experience. Why not put this knowledge to work for you . . . on a real dollar saving basis? A Dorr engineer will gladly check your recausticizing flowsheet for possible modifications.

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Progress in Alkaline Pulping in 1948*

SIDNEY D. WELLS

THE FOLLOWING review of the progress in alkaline pulping for 1948 is a continuation of the reports for the years 1946 and 1947 (*1*). Equipment and materials of construction are now available and delivery can be obtained within a reasonable time. The chief concern seems to be whether the demand for the products of alkaline pulping will continue sufficiently active after the completion of new units and improvements and the expansion of existing units to justify the expenditures involved. The greater efficiency of much of the new equipment, however, will force its adoption, whether management likes it or not. Obsolete and submarginal mills are already beginning to drop by the wayside.

EXPANSION IN THE UNITED STATES

Manufacturing capacity for sulphate pulp is being expanded much more rapidly than that for sulphite pulp, even in areas where sulphite pulpwood species are plentiful. The only factor that can save the sulphite industry in the future is the inauguration of the recovery of its spent cooking liquors in a manner similar to that in active use for many years by the sulphate pulp mills. The tonnage of kraft pulp made in the United States is now substantially as great as that of all other pulps combined and it is being increased each year several times as fast as the increase in tonnage of sulphite pulp (*2*). Sulphite mills can improve their product by the use of the magnesium, sodium, or ammonia base process; the principal feature of these processes is the possible recovery of the cooking base; the elimination of those mills not able to do this will ease the wood supply for those that can use these processes.

The completion of the new sulphate pulp mill by Brown Co. at Berlin, N. H., is an outstanding example of the new trend (*3–6*). The Champion Paper and Fibre Co. has completed a similar development (*7*). The Riegel Paper Corp. has improved its operations in New Jersey (*8*) and is managing timber limits in North Carolina for further expansion. Also, production has been increased through the new mills, improvements, and enlargements at Plymouth, N. C. (*10, 11*), Charleston, S. C. (*12*), Georgetown, S. C. (*13–15*), Brunswick, Ga. (*9*), Port Wentworth, Ga. (*16–18*), North Pensacola, Fla. (*19–21*), Palatka, Fla. (*22–24*), Panama City, Fla., Mobile, Ala., Moss Point, Miss., Springhill and Bastrop, La., and Camden, Ark. (*13–15*). A pulp mill for making dissolving pulps from southern gums is under construction at Natchez, Miss. (*15*). A newsprint mill (Coosa River Newsprint Co.) at Childersburg, Ala. (*25*) will soon join the pioneer operation at Lufkin, Tex. (*26, 27*), which has recently doubled production. Standard newsprint for southern newspapers is the objective.

Expansion has taken place not only in the South, but also on the Pacific Coast. The specialty mill at Camas, Wash. has been greatly improved (*28*). The Weyerhaeuser Timber Co. has followed the completion and operation of the bleached kraft pulp mill at Longview, Wash., with the pulp mill and container board plant at Springfield, Ore. to operate on sawmill refuse (*29*).

The Simpson Logging Co. has established its Woodfiber Division at Shelton, Wash., and is in active production of insulating wallboard and structural board (*30*). Because the company agreed to follow good practice in forest management and sustained yield logging on their timber limits, the U. S. Forest Service has set aside for their exclusive use approximately an equal volume of public standing timber for long-term operation. Extension of this practice to other operations near national forests should result in greatly stabilizing the supply of paper pulp in the older sections of the country.

A joint project of the Puget Sound Pulp & Timber Co. and the American Viscose Corp. has been announced for Ketchikan, Alaska (*31*). A 300-ton bleached sulphate pulp mill is contemplated. The Newsprint Service Bureau has prophesied no production of Alaska pulp before 1951 (*32*). General surveys of the industry and its modernization have appeared (*33, 34*). Ritchie discusses the forest resources of the South (*35*) and the directory of southern mills made its annual appearance (*36*).

EXPANSION IN CANADA

Not only in the United States but also in Canada has there been a marked trend toward the adoption of the sulphate process for future expansion, even where spruce, balsam fir, and western hemlock are still plentiful. General mention of the mills built by Bloedel, Stewart & Welch Ltd., the LongLac Pulp & Paper Co., Ltd., and the Maritime Pulp & Paper Mills is made, with special mention of Arborite, Tomlinite lignin powder, turpentine, and tall oil (*37, 38*). The Alberta Pulp Mills, Ltd., with a capacity of 175 tons of bleached sulphate pulp, is planned for Red Deer provided the Alberta government grants the cutting rights to timber from Dominion holdings of 300,000 acres west of Red Deer (*39*).

Probably the greatest activity is taking place in British Columbia, which includes Vancouver Island (*40–44*). The mills of Bloedel, Stewart & Welch Ltd., Canadian Western Lumber Co., Comox Logging & Railway Co., Pacific Mills Ltd., and the Sorg Pulp Co., Ltd., are in operation, although there is talk that the latter may not continue because of an inadequate wood supply and higher costs for operation than the others (*45–49*). Flowsheets for the various mills are also presented (*50*).

OTHER COUNTRIES

Considerable new construction, as well as revamping of existing operations, has occurred in Mexico (*51–53*). Observations on the present status in France (*54*), Belgium (*55*), the Netherlands (*56*), Western Germany (*57*), Austria (*58*), and Italy (*59*), by Joseph E. Atchison, Pulp and Paper Specialist with the Economic Cooperation Administration, indicate that, although many of the mills destroyed during World War II have been rebuilt, they have not taken advantage of the developments in North America and Scandinavia during the past 10 years and are much smaller and incapable of even approximating the same output per employee.

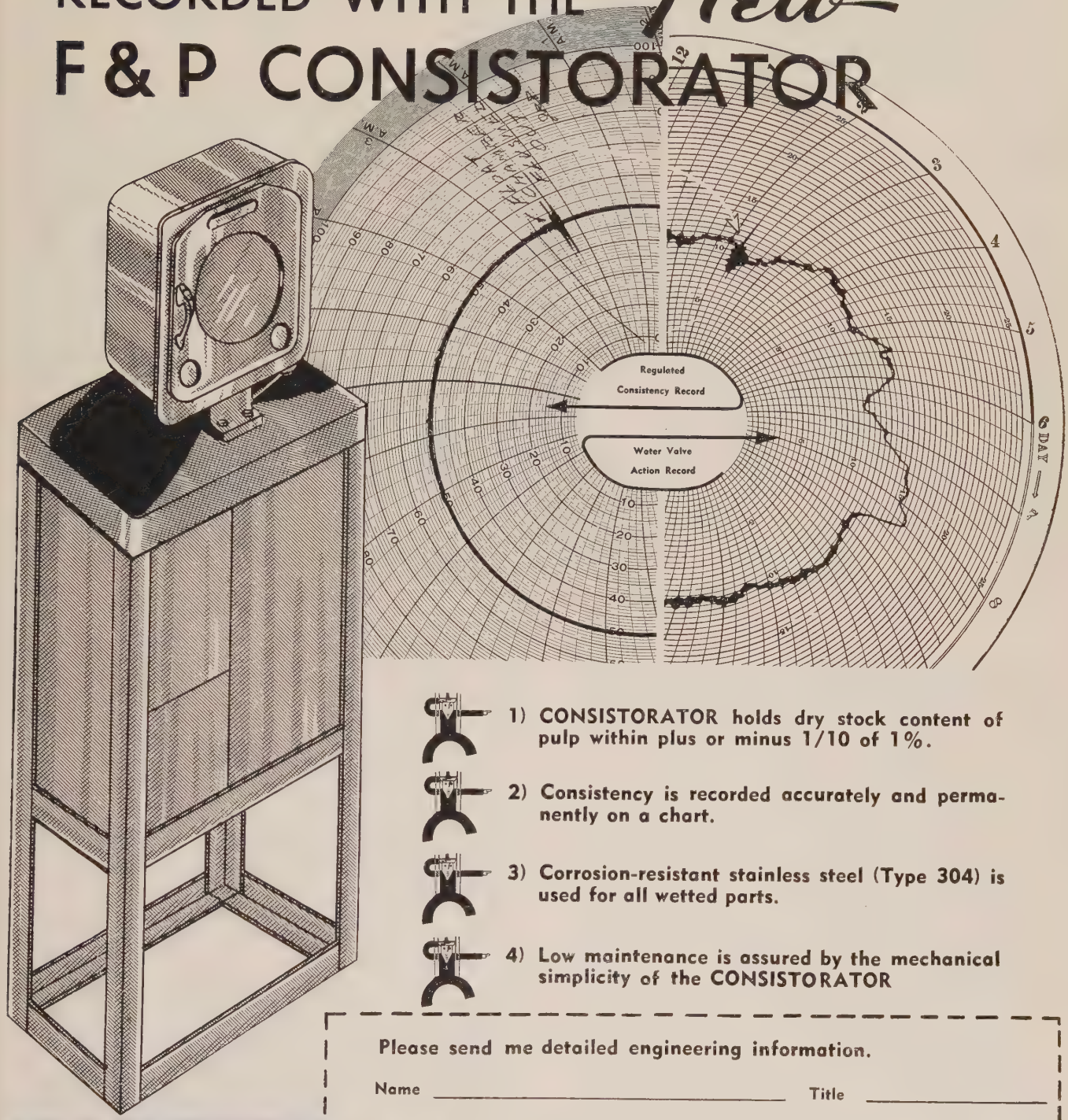
A discussion of the production of pulp, paper, and board in France is also given (*60*). The use of wheat straw for the manufacture of book, writing, drawing, printing, and other high-quality white papers is well advanced; apparently, such paper can be produced at a lower cost than when using wood pulp of comparable quality. In Italy the pulp produced at lowest cost was from straw using the process disclosed in 1928 by the writer (*61*). In the present application, a 3-week period is used for the cold soak whereas, with countercurrent use of the caustic liquor, a 3-day period is equally effective. The relatively lower cost, as compared with the Pomilio, sodium sulphite, and other processes of chemical pulping, might also be realized

* Prepared at the request of the Alkaline Pulping Committee of the Technical Association of the Pulp and Paper Industry, Henry Vranian, Chairman.

Southern Pulp and Paper Manufacturer financed this extensive report for the Technical Association of the Pulp and Paper Industry as a service to pulp, paper, and paperboard manufacturers. Written permission must be obtained from the *Southern Pulp and Paper Manufacturer* or the Technical Association of the Pulp and Paper Industry before reproduction.

SIDNEY D. WELLS, Member, TAPPI; Research Associate, The Institute of Paper Chemistry, Appleton, Wis.

STOCK CONSISTENCY CONTROLLED AND RECORDED WITH THE *New*— F & P CONSISTORATOR



1) CONSISTORATOR holds dry stock content of pulp within plus or minus 1/10 of 1%.

2) Consistency is recorded accurately and permanently on a chart.

3) Corrosion-resistant stainless steel (Type 304) is used for all wetted parts.

4) Low maintenance is assured by the mechanical simplicity of the CONSISTORATOR

Please send me detailed engineering information.

Name _____ Title _____

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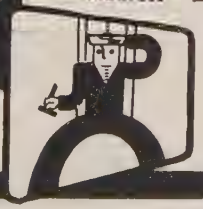
PROCESS CONTROL INSTRUMENTS

SALES ENGINEERING OFFICES THROUGHOUT THE WORLD



FISCHER & PORTER CO.

DEPT. 9Z-7P. HATBORO, PA.

in the United States by the substitution of wheat straw, cornstalks, and other fibrous agricultural residues for wood. Organization for use of the 200 million tons of fibrous agricultural residues annually destroyed in this country is certainly worthy of consideration.

Rapid expansion has occurred in Australia and new mills are being built. Pulping experiments on eucalyptus woods in 1912 and 1913 were discouraging but, with the development of methods of pulp evaluation since that time and the use of plant materials like New Zealand flax, imported softwood pulp, etc., a very active industry has developed that is now coming into its own. The present value is estimated at $40,000,000 (*62–66*).

In Japan, 90 wood pulp mills are reported, of which eight make dissolving pulp and four are devoted mainly to the manufacture of newsprint (*67*). Maps are given showing the location of the mills.

CONSUMPTION OF CHEMICALS

The most important chemicals for pulping, purification of the cellulose fiber, and bleaching are soda ash, caustic soda, and chlorine, with salt cake used to supplement the soda ash and caustic soda. Lime is important but is usually available locally, since its source was probably considered in establishing the mill. Considerable progress has been made in the Midwest (*68*). The capacity for the production of soda ash has been augmented (*69, 70*). Electrolytic production of chlorine and caustic soda has enormously increased, especially in the Southwest (*71–75, 326*). Facilities have also been instituted in Mexico and Australia (*76, 77*). The plant for mining, purifying, and drying of salt cake from the largest natural deposits of sodium sulphate in the world is operating at Chaplin, Saskatchewan (*79*). The supply and demand situation regarding the various chemicals used in the pulping processes has been reviewed (*284*).

A new process for the production of chlorine dioxide has been disclosed (*78*).

WOODS USED

The nature of the chemical components of wood and the problems involved in supply and use were discussed at the symposium held under the auspices of the Fundamental Research Committee of TAPPI in September, 1947 (*80*). "The coming age of wood" soon after appeared to call attention to the increasing use and potentialities of wood (*81*). Shortages, however, occur more often than not in the older countries, so that realization of the need for new growth and use of inferior species is important. The article on the forest resources of the world (prepared by Unasylva) presents these facts on a global basis (*82, 83*). New uses are important (*84*). The estimated investment of $16,000 to $19,000 per employee in primary pulp and paper mills of the United States [the most recent estimate for Canada is $19,000 (*85*)] is a factor in limiting paper production to the extent that it discourages new capacity.

A review of products from pulp and pulpwood on the Pacific Coast indicates recent progress (*86*). Apart from the enormous tonnage in kraft, semichemical pulp—both kraft and neutral sulphite—is rapidly gaining ground. Bleached, long-fibered sulphate pulps are also increasing rapidly in tonnage. Converting plants to complete the integration are increasing in number. Kraft wrapping paper and envelope paper are two important outlets for unbleached and bleached kraft pulp (*88, 89*). Forest management by well-trained forestry staffs is becoming common practice (*87*). The economic background, and the pulpwood supply and production in the southern United States have been discussed by several writers (*90–93*).

The origin and development of the semichemical process, particularly as applied to the pulping and making of paper therefrom, occurred in the middle 1920's by members of the staff of the Forest Products Laboratory. It was apparent from the start that aspen, birch, maple, southern gums, oaks, ash, etc., were admirably suited for unbleached pulps which could be bleached when the brightness of the unbleached pulp was inadequate. At that time, there were enormous quantities of extracted chestnut chips available at the leach casters at from 50 cents to 2 dollars per ton. As a consequence, the first extensive commercial development on a large scale was on this material. The need for the extension of production is obvious and desirable (*94*). The application of the semichemical process to New England hardwoods has been proposed (*95*). The ownership and availability of pulping species in the Lake States is discussed (*96*). The supplies of pulpwood in Colorado and Eastern Montana (*97*), Saskatchewan (*98*), Alberta (99), Great Britain (100), the French colonies (*101*), and tropical areas (*102*) have been considered.

With the threat of curtailment of export from Canada, the Lake States mills are establishing and building up industrial forests; the Southern Pulpwood Conservation Association is intensely active; "Tree Farms" are being encouraged; and, in many ways, efforts to reach self sufficiency and sustained yield are under way to furnish the 20,000,000 cords of wood annually consumed (*103*). Canadian efforts to safeguard their pulpwood empire are not lacking (*104, 105*). Prelogging and other reforms along European and eastern lines will avoid the enormous logging waste in high-line logging on the Pacific Coast (*106*). The Swedish answer is scientific management (*107, 108*).

In the utilization of wood waste, economic considerations must never be ignored (*109*). On the Pacific Coast, there is an abundance of wood waste (*110*) which makes greater utilization of tops desirable (*111*). Pulping developments of wood wastes are being studied (*112–114*). Slab waste from the sawmill is used in the sulphate mill at Port Alberni (*115*). At Thunder Bay, the woodroom refuse is burned with a saving of 10 to 19 tons of coal (*116*).

In the use of pulpwood, closer utilization of black spruce has been studied (*117*), as well as white spruce reproduction and cutting limits in Manitoba and Saskatchewan (*118, 119*), growth of balsam fir in Newfoundland (*120*), tree grades for loblolly and shortleaf pine (*121*), linerboards from jack pine and hardwood semichemical pulps (*122*), the use of fire-killed pine from southwestern Maine (*123*), and Spanish investigations on *Pinus pinaster* (*124*). Surveys of the properties, uses, and grades of white fir (*125*) and larch (*126*) have been published. The salvage operations in the Douglas fir region (*127*), the use of thinnings (*128*), and the application of the hydraulic barker to Douglas fir saw logs (*129*) have been discussed.

Poplar is coming into its own for pulpwood and its use has been extended by studies and cultivation of hybrids (*130–136, 283*).

Beechwood pulp has been improved in quality by prehydrolysis, leading to the production of furfural as a by-product (*137*). Oak is suggested for soda pulp in Florida (*138*).

The rapid extension of papermaking in Australia has prompted several articles (*62–66, 139, 140*). The semichemical processes seem well suited for the various eucalyptus species (*309, 310*). Plant maintenance is a problem because of corrosion (*141, 142*).

Hardwoods deserve consideration for pulp making in India and in the French colonies (*143, 144*).

PULPING PROCEDURES ON VARIOUS SPECIES

TAPPI Data Sheet 150 (*145*) reproduces curves showing pulpwood loss by sinkage and its deterioration under various

NEW ARMSTRONG *Individual Dryer* TEMPERATURE CONTROL

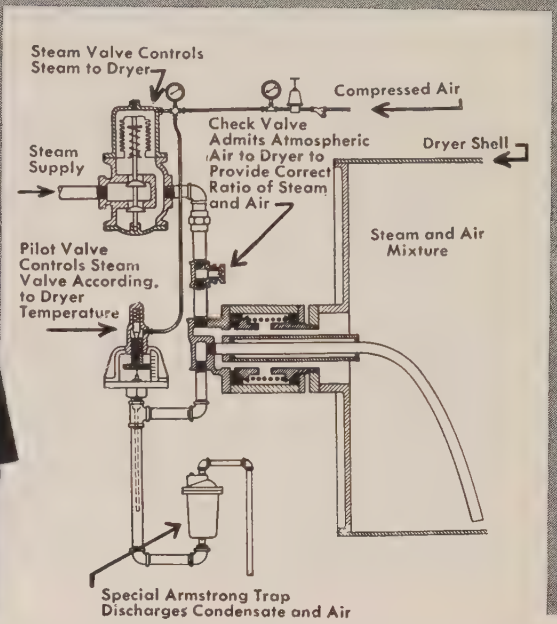
Keeps Wet End Dryers "Cool"

Prevents Sheet from Sticking and Curling

Controls Each Dryer Independently

Maintains Any Temperature from 100° to 250° F

Positive—Dependable—Guaranteed


Steam Valve Controls Steam to Dryer
Compressed Air
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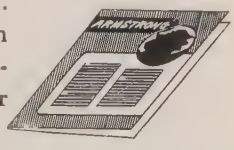
Steam and Air Mixture
Pilot Valve Controls Steam Valve According to Dryer Temperature
Special Armstrong Trap Discharges Condensate and Air

Armstrong Individual Dryer Temperature Controls on the wet end of a paper machine make it possible to increase the sheet temperature as slowly as required for good drying. The temperature of the first dryer can be set at say 140° F, and that of the succeeding dryers at 160°, 180°, 200°, and 220° or whatever setting may be required for drying a particular sheet.

Thus, we have a positive, dependable answer to an old drying problem: maintenance of relatively cool wet-end dryers to prevent the sheet from sticking to the dryer surface, and to avoid curl or cockle due to over-drying on one side.

These controls are also used after the size press. Not only are the non-picking, non-curling advantages secured, but here fairly constant control of moisture content is also secured.

For complete information on this proved method of improving paper drying, write for BULLETIN 187



Reduced Temperatures Secured by Controlled Mixture of Steam and Air

When steam and air are mixed at atmospheric pressure, the temperature of the mixture will be that corresponding to the partial pressure due to the steam. For example, if the partial pressure of the mixture due to steam is 3.7 lbs. absolute, the temperature will be 150° F. The Armstrong Control diagrammed above automatically controls the ratio of steam and air to maintain accurately the temperature for which it is set. If the temperature of the dryer tends to rise, the pilot valve bleeds compressed air to release pressure on the steam valve bellows, causing it to throttle. A decrease in temperature causes a reverse action. Atmospheric air for the mixture enters through the check valve when the condensing rate of the dryer causes pressure to drop below atmospheric. When temperatures above 212° F are desired, the check valve stays closed, no air enters and steam pressure is raised to the required point.

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conditions. The relative merits of dry, green, or stored wood (*146*), the effect of submersion on the decay of pine (*147*), the relation of wood quality to its resistance to decay (*148*), and the raw material problems in the cellulose industry have been studied (*149*). The effect of insect attack on lodge pole pine (strength of wood, digester capacity, pulp properties, and yields) are reported by the Forest Products Laboratory (*150*). The properties of semichemical pulps from beechwood are interesting, especially the yields and pulp strength (*151*).

A great deal of information on pulping experiments made in Japan during the late war—particularly the pulping of red pine (*152, 153*)—is now appearing. Comparative pulping studies using sulphate and sulphite cooks were made with Japanese larch, Lauan wood, and red pine (*154*). The deciduous trees of Hokkaido were studied as a source of rayon pulp (*155*). The action of sodium hydrosulphide in pulping (*156*), the caustic pulping of kozo (*157*), the pulping and extraction of wattle wood for tannin (*158, 163*), the alkaline pulping of Manchurian "Dahurica-Karamatsu" and morphological and chemical studies of this wood (*159, 160*), pulp from decayed "Sirakanba" birch (*161*), and tropical woods (*162–164*) have been covered.

AGRICULTURAL RESIDUES AND GRASSES

With wood costing $35 per cord in European countries, and with spruce available at approximately the same price in the United States, it seems appropriate to review completely the relative economic position of straw, cornstalks, bagasse, soybean straw, alfalfa fiber, and the other fibrous agricultural residues that exist in amounts of over 100,000,000 tons per year in the United States, and which are now largely destroyed or wasted. Wheat straw was used in large quantities before the Civil War for the manufacture of news, book, and writing papers, as well as for wrapping paper and board. The newsprint made from wheat straw has withstood the use and exposure to which it has been subjected in our public libraries much better than the newsprint made since then from wood pulp. The replacement of straw by wood was the result of the cheapness with which wood (until then an untouched source of fibrous material) could be obtained. Prices of about $4.00 per cord delivered to the pioneer mills were the prevailing rates in the 70's. Because of the complete elimination of straw from the fine-paper field by the then low cost of wood, the technique of pulping straw for white paper was forgotten to a considerable extent. However, the urgency of a supply of papermaking fibers during and since the late war has led to a revival of interest in this raw material. Many mills are now using straw for white-paper manufacture and, with the improvements in harvesting machinery and the organization of collection, a substantial supply at competitive prices seems possible. The same forces are also working toward the utilization of other fibrous agricultural residues and the recent literature on the subject is voluminous. A comprehensive review of the situation in 1948 includes wheat straw, bagasse, cotton stalks, and flax (*165*). German technicians are also exhaustively investigating this problem (*166*).

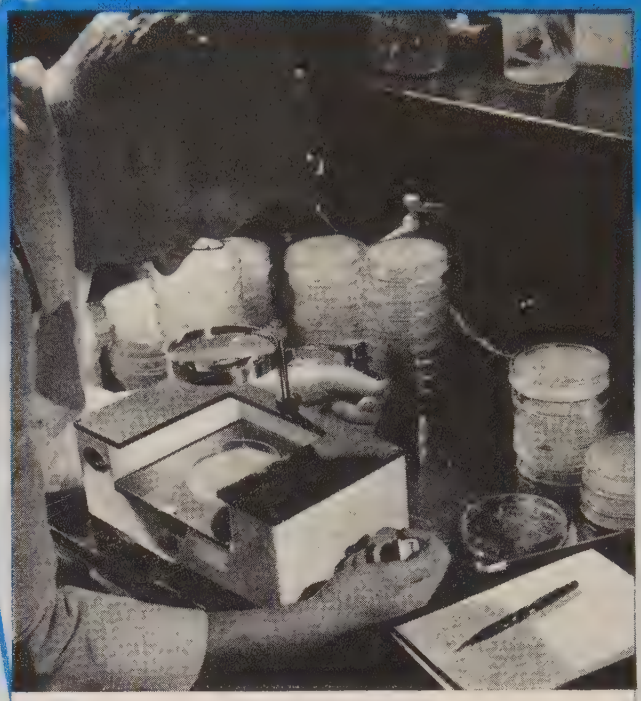
The TAPPI Agricultural Residues Committee is very active (*167, 168*). Among its interests are methods of collection and the quality of straw for the straw board industry (*169*). The use of the semichemical process [using sodium sulphite and carbonate, which is similar to the Nuprocess and Strawkraft processes (*170*) of the late 1920's] is discussed (*171–173, 282*). A comparison showed the advantages of the neutral sodium sulphite and the kraft process for straw pulping (*174, 175*). A study of the holocellulose isolated from straw, using sodium chlorite as the pulping agent, is reported (*176*); the present high price of sodium chlorite makes the process prohibitive from a practical standpoint. The Spanish people are also interested (*177*). The production of wallboard from straw as a small rural industry is discussed (*178*). More information on the Morley continuous pulper is recorded and a comparison is made with the Huguenot pulper (*179, 180*). Observations in Ohio show that leaving the straw on the land is injurious to clover seedings that follow (*181*).

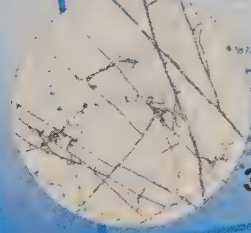
During the past 10 years, the use of wheat straw in Europe for the manufacture of printing and writing papers has been expanded. In England, equipment for pulping esparto was utilized. It is felt that further development is necessary to integrate the sources of supply, eliminate weeds, modify the plant to better fit the pulping requirements, and really make a serious effort to obtain the maximum benefits inherent in the material (*182–186*). In the Netherlands, France, Germany, and Italy (*54, 56, 57, 59*) commercial utilization has long been practiced. In Germany production of yeast for food as a byproduct has been developed (*187*). Recent runs on a plant scale in the United States indicated the possibility of newsprint manufacture (*188*). Use of straw for board manufacture (*189*), the chemical composition of straw (*190*), and a rapid estimation of moisture of straw in bales (*191, 192*) are discussed. Much progress has been made in the prevention of deterioration and decay of baled straw in stacks (*193*).

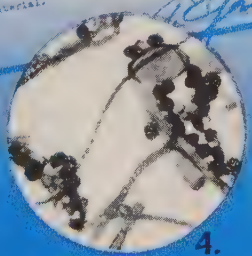
Before World War II, most of the paper used for cigarettes was imported from Europe. It was made largely from linen rags. In the United States, Canada, and the Argentine, enormous quantities of flax straw, obtained as a waste product in the production of flax seed for linseed oil, are available. For many years the U. S. Department of Agriculture at Washington, D.C. and Madison, Wis., studied the decortication and pulping of flax straw in order to utilize the bast fiber instead of the linen rags obtained largely from Europe. The Forest Products Laboratory, in the early 1920's, worked out the use of modified kraft cooking liquors, chlorination, and multistage bleaching. With the threat of war in the late 1930's and the probability of the stoppage of linen rags and cigarette papers from Europe, the few paper mills engaged in the manufacture of cigarette, condensor, carbon, and India papers in the United States adapted the modified kraft process to their operations; one large importer built in North Carolina the largest plant of that kind so that, when the supply from Europe was cut off, the manufacture of cigarette paper from flax straw in the United States and Canada was well established. About one fifth of the flax straw produced annually in the United States (amounting to 60,000 tons) is utilized. In Canada, the proportion is much less and in the Argentine, it is practically none, regardless of the fact that the amount available is equal to that in the United States. Establishment of pulp-producing units comparable with those in the large wood-pulp mills would make available to the fine-paper industry quantities of superior fiber that would benefit greatly many of the best papers which are produced. Sufficient fuel from the decortication of the straw is available to supply all the power and steam requirements of the entire pulping operation. In a general discussion of the present status of the industry (*194*) no mention is made of the pioneer work at Madison, Wisconsin in 1919, when modified kraft cooking liquors were used in pulping flax tow with promising results. An improved process of decortication is disclosed (*195*). A general article on the utilization of linseed straw (*196*) and one on Brazilian possibilities (*197*) are available. Work has been done with flax shives (*198*).

Jute (*199, 200*), ramie (*201*), hemp, old bagging, and rope (*202*), Indian and Australian fibrous materials (*203, 204*), and alfalfa—after concentration of its nutrients—are promising sources for fiber (*205*).

Successful Nalco Slime Control







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Analysis No. 65432
Sample Taken August 2[illegible], 1949
Sample Received August 3[illegible], 1949
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MOST TROUBLESOME TYPES
FUNGI
YEAST-LIKE
STEP 1.
MICROBIOLOGICAL ANALYSIS
1.
2.
3.
4.

Above and at right are four microphotos of slime-forming organisms commonly found in paper mill systems: (1) B. mesentericus, (2) Aspergillus niger, (3) Trichoderma, and (4) Oidium.

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No further proof is needed of the technical and economic place of bamboo in papermaking (*208–210*). Reeds and Savannah grass are also important in India and China (*211–213*).

Bagasse is now an industrial raw material of established importance (*214–220*). The above discussion of straw and bagasse also applies to cornstalks, especially with the improved methods for segregating its fibrous and nonfibrous constituents with total yields of over 50% (*221–223*).

In Germany much interest is manifest in the pulping of perennial shrubs, especially broom (*224–228*).

COOKING PROCEDURES AND DIGESTER FACILITIES

Because of the rapid expansion of pulping facilities in India and the approaching attainment of self-sufficiency, generally descriptive articles appear, of which the one by Sergeant is an example (*229*). Most of the advance in the field indicated in the heading is disclosed in the patent literature (*230–234*). Studies have indicated definite superiority of the kraft process when applied to black spruce (*235*). The origin of the kraft color has also been studied (*236*). Continuous digestion is gaining in interest. In addition to the cold-pulping process (*61*), the two-stage countercurrent process (*221–223*), and the Morley and Huguenot processes (*179, 180*), Maskau and Richter (Kamyr) processes have been described (*237, 238*). A patent (*335*) discloses complete, continuous pulping without the necessity of mechanical disintegration. A general description appeared in *Unasylva* (*286*). Automatic control, combined with indirect heating and forced circulation, is also in use (*287*).

Advance in the removal of odor is indicated (*243*); black liquor is heated in a gas-tight zone at 200°C; the liberated gases are condensed.

FOAM

Foam may be a very serious impediment to pulp and paper manufacture, even to the stoppage of operation. Fundamental studies may lead to effective prevention or cure (*239–242*).

TALL OIL AND TURPENTINE RECOVERY

Progress has been made in the utilization of sulphate turpentine and tall oil. Chemical uses for turpentine and methods for refining are suggested (*244, 288*). Terms relating to tall oil are being standardized (*245*). The fuel and soda value of tall oil are presented in the form of a TAPPI data sheet (*246*). The second supplement to the annotated bibliography published in 1942 has appeared (*247*). Many articles of a descriptive and review nature have appeared (*248–252*). The study of solvent extraction has been extended and the separation of the various components is still of interest (*253–256*). Distillation requires aluminum tanks to avoid corrosion (*257*). Hydrogenation can also play a part in the utilization of tall oil (*258, 259*). Variations in the composition of tall oil are geographical in nature; only slight differences were observed in pulpwoods cut at various seasons (*260*).

Now that the naval stores and animal and vegetable fats and oils are back to normal or in plentiful supply, research in tall oil is being extended to products that can be made therefrom and to possible outlets (*261, 262*). Substitutes for linseed oil in linoleum, paints, and varnishes (*263–265*) are discussed. Information about Pentek resins, tall oil, paints, rubberlike polymers, and tall oil-cellulose ethers combinations (*266–269, 289*) is also available.

TESTING METHODS

Methods for the estimation of free and total alkali in straw and esparto black liquors (*270*), the analysis of tall oil (*271*), the rapid determination of the components of tall oil varnish (*272*), and tests for volatile sulphur compounds in sulphate turpentine (*273*) have appeared. The TAPPI Standard for the analysis of black liquor has been revised (*291*). The chemical control of sulphate black liquor recovery has been discussed (*290*), and a "per cent solids scale" (*293*) has been developed for the determination of the solids content of causticizing muds.

RECOVERY OPERATION AND EQUIPMENT

Recent recovery furnace developments give more steam (*274*). Examples of maintenance problems in an integrated kraft mill (*293*), a review of evaporation progress in 1948 (*294*), and a simplified method for estimating evaporator performance (*295*) are available. The recovery of heat and chemicals from the recovery furnace has been considered (*296, 297*), and a bibliographical summary of the whole subject has been prepared (*298*). Apparatus design and performance are discussed (*299–302*). Improvements have been made in causticization (*275, 276, 334*) and in the washing of the caustic mud (*277*). The reburning of lime mud in a rabble-type furnace is described (*278*). Suggestions are also made for decreasing white liquor consumption (*279*). Causticization of the effluents without incineration is proposed (*280*). Studies have been made on storage basins for kraft mill wastes (*281*) and on trickling filters for alkaline wastes (*333*). Numerous articles have appeared on the performance of Cottrell precipitation (*303–305*). The possible uses of the Koppers-Elex electrical precipitator are reviewed (*306*). The size of the rotary kiln needed for burning lime is discussed (*307*), and an account of methods for causticization is given by Dolgov (*308*).

PURIFICATION AND BLEACHING

Progress in multistage bleaching has continued (*311–315*). Integration of power, salt, electrolytic plant, and kraft pulping is important (*316*) and is illustrated by the reconverted Espanola mill. The development of high-density bleachers, chlorinators, washers, etc., operated by remote control direct motor drives, have resulted in a highly complicated procedure but one which requires very little man power and gives high production and quality (*317*). A round-table discussion on bleaching was held (*318*). The preparation and use of bleached wood pulp in Russia has been described (*326*). An extended discussion of the manufacture and uses of chlorine (*319*) has been prepared by Lamie and MacMullin.

The use of multistage chlorination and bleaching, with a final treatment with chlorine dioxide and sodium or hydrogen peroxide, is proposed for producing pulp of high brightness and strength and with a minimum degradation of the cellulose (*320*). Some attention is being given to the use of sodium chlorite (*321–323*) and in patents (*324, 325*). The use of fluorescent bleaching agents is proposed for textiles, some of which may justify the cost (*327*).

Observations on the discoloration of bleached bamboo pulp after storage are given, with the recommendation of more thorough washing and scouring with sulphurous acid (*328*). The bleaching of groundwood pulp received considerable attention (*329–331*). A new system of bleaching groundwood with zinc hydrosulphite is described (*332*).

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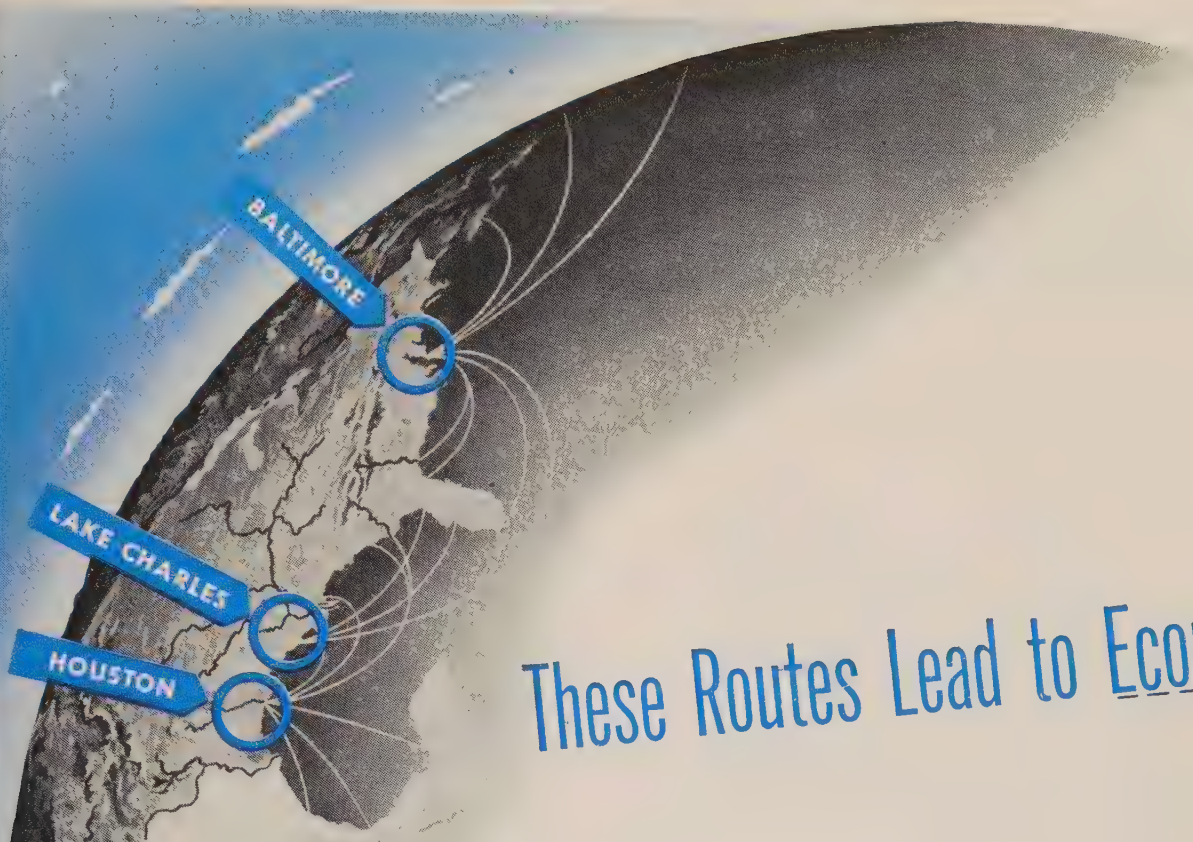

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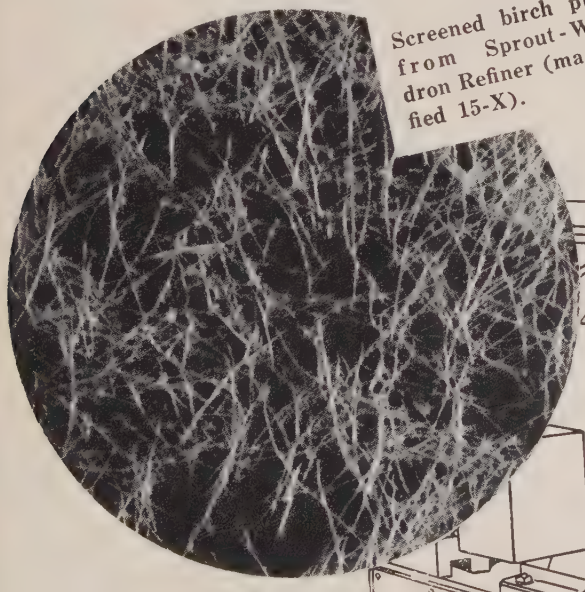

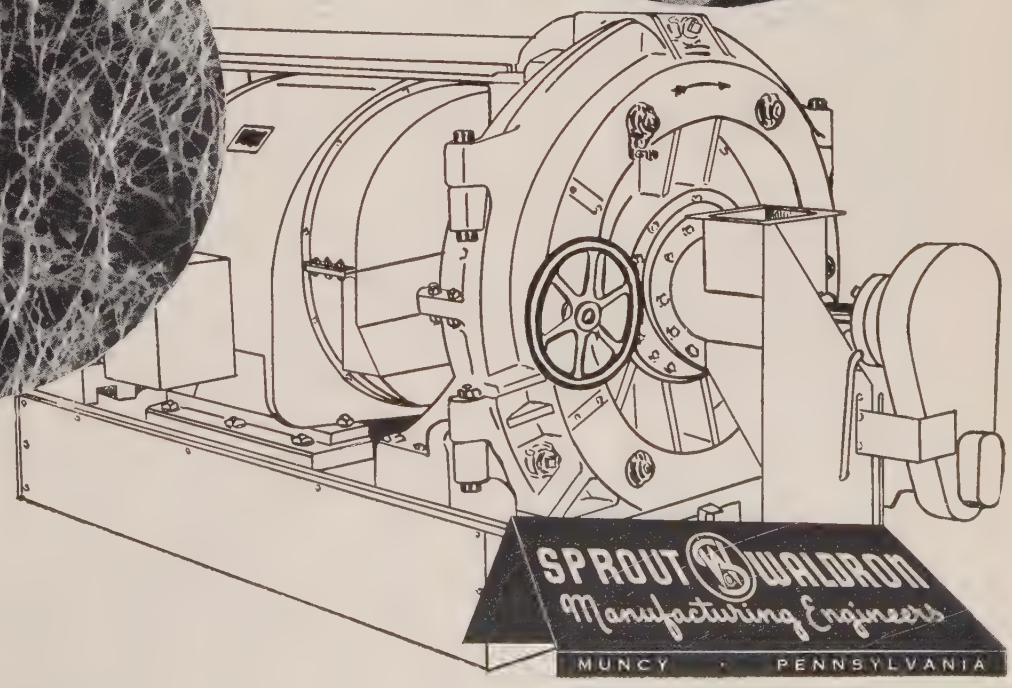

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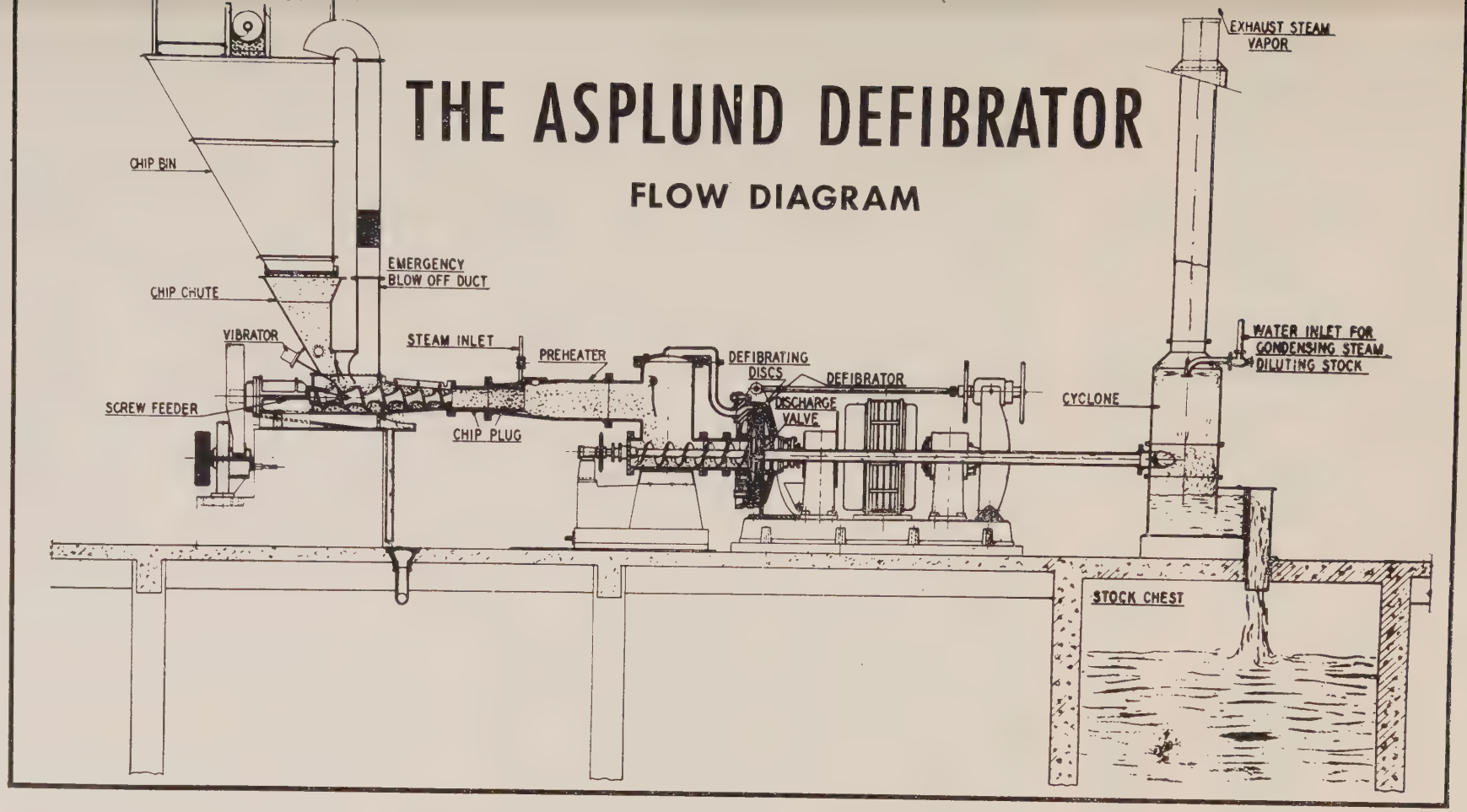
THE ASPLUND DEFIBRATOR

FLOW DIAGRAM



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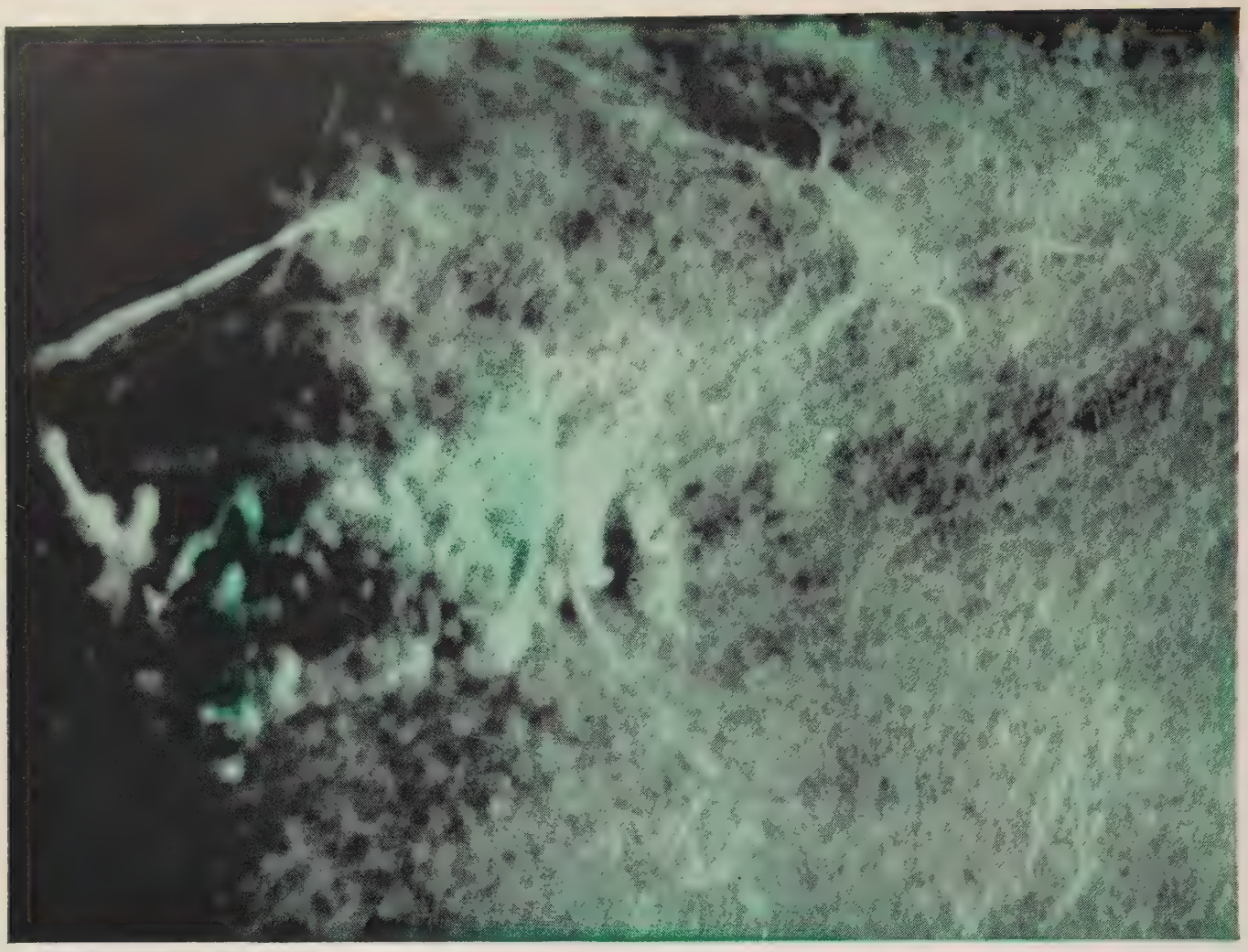

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CHEMICALS INDISPENSABLE TO INDUSTRY AND AGRICULTURE

The Centrifugal Clarification of Sulphate Liquor

A Report on Experiments with White and Green Liquors

A. E. REED and W. F. GILLESPIE

A description of the equipment, experimental layout, and experimental procedure is given. The effect of six variables on the clarity of white liquor were studied with the following findings: Variation in centrifuged liquor rates up to 10 g.p.m. had little effect on the white liquor clarity. Above this rate the per cent solids in centrifuged liquor increases rapidly as the rate increases. At a liquor rate of 10 g.p.m. the per cent solids in the centrifuged liquor increases rapidly if the solids in the feed are increased above 11%. Clarity of the white liquor is adversely affected by high percentages of free CaO. Per cent solids in the centrifuged white liquor increase as the temperature decreases. Activity of the white liquor had no appreciable effect on its clarity. Green liquor solids in the causticized liquor are not effectively removed in the centrifuge. The solids remaining in centrifuged liquor were more difficult to remove by secondary clarification than solids remaining in tray clarified liquor. Green liquor could not be clarified in this type of centrifuge.

CENTRIFUGAL separation of solids from liquors is standard practice in many industries. In the paper industry centrifugal filters effect a satisfactory separation of lime sludge from liquor on the under flow from clarifiers.

In the experiments reported in this paper an effort was made to study the clarification of liquor from the causticizing operation. The experiments were conducted at the plant of the Gaylord Container Corp., Bogalusa, La., in cooperation with the Bird Machinery Co., whose centrifugal filter was the main equipment in the experimental layout.

DESCRIPTION OF FILTER

The filter used is illustrated on Fig. 1. It consists of revolving bowl and a screw conveyor which rotates inside the bowl at a slightly slower speed in the same direction of rotation. The driven sheave is rigidly connected to the outer of the two concentric shafts; this drives the entire bowl. The screw conveyor which removes the solids is driven through the solids conveyor gear drive.

The bowl is 18 inches in diameter and 28 inches long, and is driven from a 10 hp. motor through V-belts. The internal parts which come in contact with the slurry are constructed of 304 stainless steel.

The feed slurry enters the filter through a stationary feed pipe which is concentric with the two drive shafts. The feed is discharged into the conveyor hub and is delivered to the revolving bowl through the feed ports in the hub. The solids from the slurry are deposited centrifugally on the inner surface of the bowl and the screw conveyor moves the solids forward continuously and discharges them through the solids discharge ports.

The liquor builds up until the level reaches the adjustable filtrate ports and falls by gravity into a sump for measuring and sampling.

The clearance between the bowl and the conveyor is about one-eighth of an inch over two-thirds of the bowl's length. The conveyor has a taper which causes the formation of a cake which has greater thickness at the solids discharge end of the filter. The solids are carried above the level of the liquid for about one-quarter of their travel through the filter before they are discharged, giving a drier sludge.

The speed of the revolving bowl is a compromise on the efficiency of separation and the mechanical disadvantages of high speed. The manufacturer of the equipment believes that a force of about 1000 G. is the best compromise for this type of slurry.

The separating force $F = k(r.p.m.)^2 \times D \times G$ where D is the diameter of the bowl in feet and k equals 0.00017. Thus a separation force of 915 G. was obtained with a 1745 r.p.m. motor with a 13-inch diameter sheave on the motor and a 12-inch diameter sheave on the centrifugal.

EXPERIMENTAL PROCEDURE

The schematic layout for the experimental plant is shown on Fig. 2. Two centrifugal units were used; one for sludge separation and the other for sludge washing. Feed lines were arranged so that regular mill causticized liquor and liquor from an experimental batch causticizer could be used as well as unclarified green liquor.

Scope

The experimental work was divided into three parts: (1) preliminary tests; (2) continuous running period on mill liquor; and (3) tests on experimental causticizer slurries which could be controlled to give desired conditions.

The preliminary tests were of short duration. They were conducted to determine the clarification of liquor at different rates. This was important since the experimental equipment had to clarify the liquor at a rate of 10 g.p.m. of centrifuged liquor to be equivalent to satisfactory operation on a commercial unit. In these tests the rate was fixed just long enough to obtain a set of readings and samples then changed to the next rate to be studied. These studies were exploratory and the data are not reported.

The continuous runs were made over a period of about two weeks during which time the filters were

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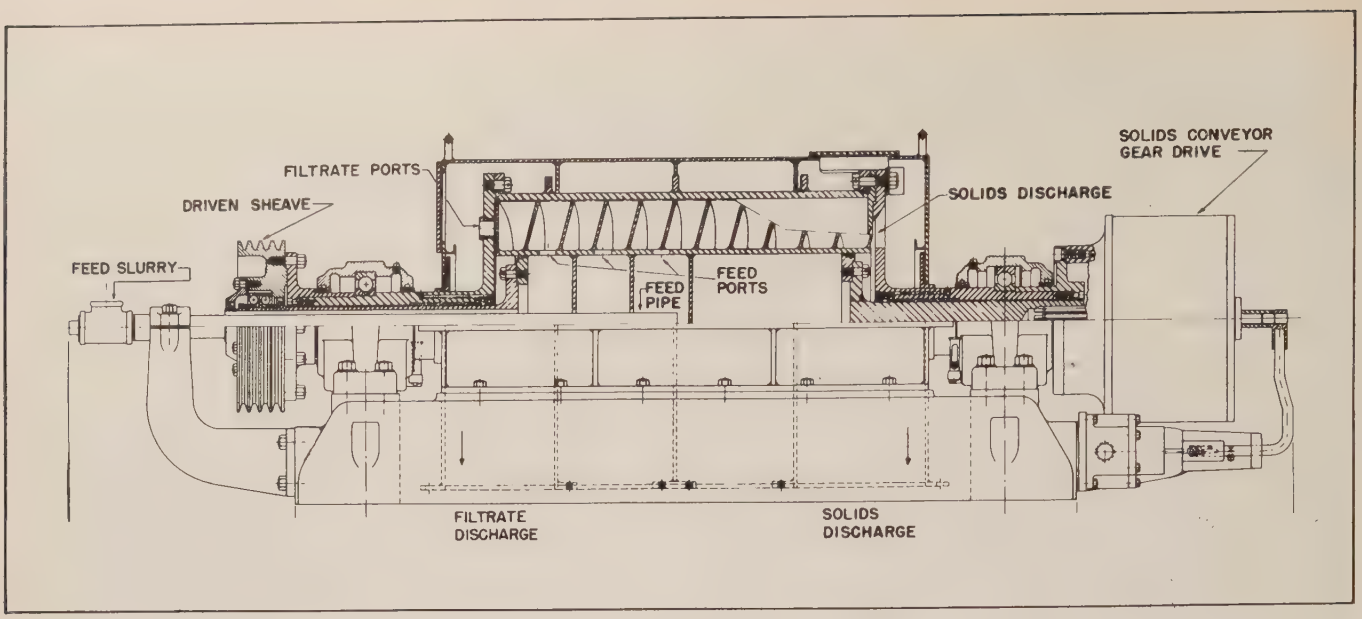

Fig. 1

operated a total of 290 hours. Every hour a check determination was made on the rate and a complete set of samples taken. During this time the rate was held at 10 g.p.m. of centrifuged liquor for 263 hours; at 8 g.p.m. for 24 hours; and at various rates ranging up to 14.5 g.p.m. for 3 hours.

In the third set of tests the feed was taken from an experimental causticizer. Under this condition the properties of the slurry, per cent solids, activity $(OH^- + S^=)/(OH^- + S^= + CO_3^=) \times 100$ as Na_2O, free calcium hydrate as CaO (available CaO), and temperature could be controlled and a feed of constant composition maintained. During these tests exact data were collected on liquor quality with varying feed rate at a constant temperature and also on varying temperature at a constant feed rate. Duplicate samples were taken at each rate and each temperature setting.

Sampling and analyses were as follows:

1. *Feed*
   (a) Total suspended solids
2. *White liquor from centrifugal*
   (a) OH^-, $S^=$, and $CO_3^=$ — activity
   (b) Total suspended solids
3. *White liquor from tray clarifier for comparison*
   (a) OH^-, $S^=$, and $CO_3^=$ — activity
   (b) Total suspended solids
4. *Green Liquor being Causticized*
   (a) Total suspended solids
5. *Wash Liquor*
   (a) Total suspended solids
   (b) Total alkali as per cent Na_2O
6. *Sludge after Wash Filter*
   (a) Total solids
   (b) Alkalinity (total alkali/total solids (1) $\times$ 100
   (c) Per cent available CaO

The data taken during the continuous testing period covered as wide range of values of each variable as possible.

These data were used to study the effect of all variables except feed rate and temperature. In analyzing the data each variable was taken in turn and the tests selected in which all other variables remained within reasonable limits. These selected tests were then divided into groups which were fixed by small increments in the value of the variable being studied. Average values of all variables for each group were then calculated. In this manner the variable being studied varied over its widest possible range and the others were reasonably constant.

The data taken during the third series of tests were more easily analyzed. The conditions could be controlled and all variables were held constant during the tests. With as uniform feed as possible to produce, the rate was varied over the widest possible limits and then with the rate held constant the temperature was varied over the widest practical limits. The effect of all these variables on the quality of the white liquor will be discussed in later sections.

In addition to these tests on causticized liquor, tests were run on unclarified green liquor to determine the degree of separation of green liquor solids that could be obtained.

Variables Studied

The mechanism of tray settling and centrifugal clarification of causticized liquor is quite different.

In tray settling, large particles by their attraction

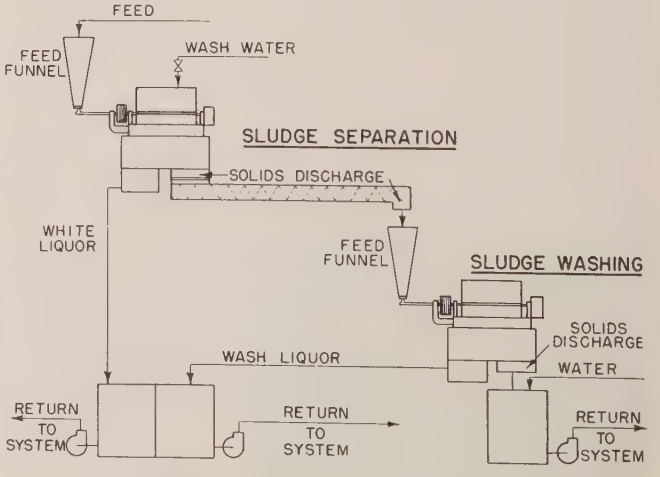

Fig. 2

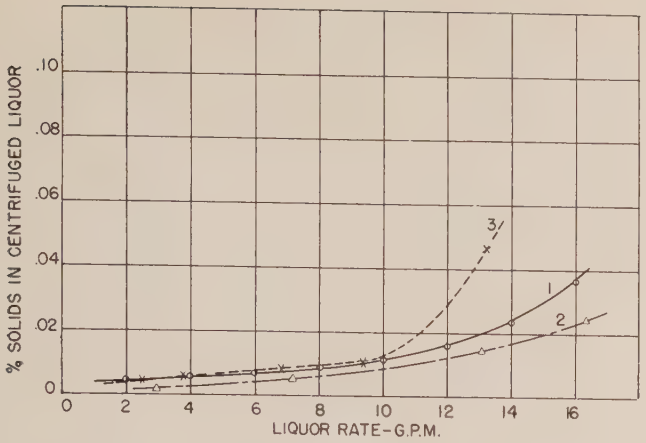

Fig. 3. Effect of feed rate on clarity of white liquor

and sweeping action carry down small particles which, if left alone, would settle at a much slower rate. As a result the liquor above the line of subsidence is clear and the slower the settling rate the clearer the liquor. In centrifugal clarification the forces are acting on the slurry for only seconds; therefore, the particles travel through the liquor at a much faster rate and there is little attraction or sweeping action by the larger particles. As a result, each particle must depend upon its own force to move it through the liquor. Because of these differences the authors felt that, though the effect of variables in tray clarification are well known, it was unsafe to assume that the variables would affect centrifugal clarification in the same manner.

In the subsequent data reported, the following variables were studied: (1) feed rate, (2) temperature, (3) solids concentration in the feed, (4) available CaO in the solids, (5) activity of the clarified white liquor, and (6) solids concentration of the green liquor being causticized.

TEST RESULTS

Effect of Feed Rate on the Clarity of White Liquor

To eliminate the effect of other variables, a mill causticizer was cut out of the line and held at 190°F. until causticizing was complete. This was used as the feed source in studying the effect of a change in rate of feed. Four batches of liquor were studied on successive days. The data accumulated are shown on Fig. 3. Curve 1 is the average curve for the four tests, curve 2 presents the data for the test in which the per cent solids in the centrifuged liquor was lowest, and curve 3 the test in which the per cent solids in the centrifuged liquor was highest.

The agreement in the data was very good up to 10 g.p.m. centrifuged liquor after which there was considerable variation. At 10 g.p.m. the average per cent solids in the white liquor was 0.012% and the solids did not reach 0.02% until the average rate was increased to 13 g.p.m. centrifuged liquor. In a later section more will be said about the quality of liquor needed for cooking and a comparison will be made between the white liquor from clarifiers and centrifuges.

Effect of Temperature on the Clarity of White Liquor

At the end of each study on feed rate the liquor was heated through a heat exchanger to the highest temperature possible and then cooled with water through an exchanger to various lower temperatures.

Settling rate in tray clarifiers is decreased with decrease in temperature due to increase in density and viscosity of the liquor. Apparently the same factors effect centrifugal separation since feed temperature was found to have considerable effect on the clarity of the white liquor.

On Fig. 4, the relation between solids in the centrifuged liquor and the temperature of feed liquor is shown. In each, percentage solids was roughly doubled for a reduction of 30°F. from 195°F.

The rate of feed was varied between experiments with approximately the same per cent solids in the feed. The authors are unable to explain the fact that all the curves do not show the same rate of change of solids in the centrifuged liquor with temperature change. Curves 1 and 2 show some erratic values and in their opinion curves 3 and 4 seem a more likely relationship.

Effect of Solids Concentration on Clarity of White Liquor

The effect of the per cent solids in the feed on the clarity of the white liquor is shown on Fig. 5. The data were taken at a centrifuged white liquor rate of 10 g.p.m.

Normally the solids in the feed is about 9% and this concentration is close to a critical point. For example, at 11% solids in the feed there is a sharp increase in the solids remaining in the white liquor.

If the feed (sp. gr. 1.27) contains 9% suspended solids and the sludge is discharged at 60% solids, this is equivalent to a feed rate of 11.08 g.p.m. for a production of 10 g.p.m. (sp. gr. 1.20) centrifuged liquor. If the production of 10 g.p.m. of centrifuged liquor is held constant, then at 11, 12, and 13% solids in the feed the gallons per minute of feed liquor become equivalent to 14.12, 15.73, and 17.4, respectively, at 9% solids in the feed. It was shown above that satisfactory operation could not be maintained at these rates. It appears that the removal of the solids is a critical factor in the operation of a centrifugal separator.

The five points shown on Fig. 5 were taken with all other measured variables held very closely con-

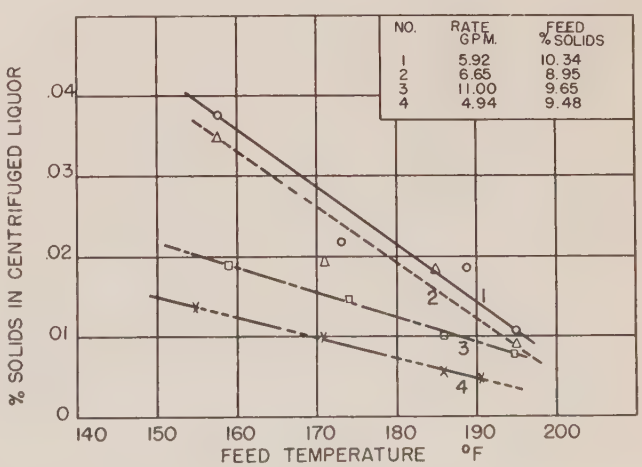

Fig. 4. Effect of temperature on clarity of white liquor

stant. Data at higher per cent solids in feed indicate that the line will continue as a straight line as shown. Points at higher values (not shown) were disregarded since the other variables, especially per cent available CaO, were increasing and were possibly affecting the results.

In tray clarification of white liquor the variation of per cent solids in the feed over the range studied had no effect on the clarity of the white liquor. The long retention time in the clarifier has a leveling out effect and if there is any variation it shows only in the amount of mud in the bottom of the clarifier. In centrifugal clarification, this averaging out is not possible. For example, if the feed has 9% solids, the white liquor should have slightly over 0.01% solids. Any excess solids in the feed is immediately reflected in the clarity of the centrifuged liquor and may finally produce liquor unsatisfactory for pulping. The authors believe that when centrifugals are used this variable must be held to much narrower limits than in tray settling.

Effect of Available CaO in Sludge on Clarity of White Liquor

In centrifugal separation a detrimental effect was encountered as the per cent available CaO increased. The extent of the effect of this variable is shown on Fig. 6. Normally the available CaO in sludge runs about 1 to 3% at which value the per cent solids in the clarified liquor will run about 0.012% if the centrifuged liquor rate is maintained at 10 g.p.m. as shown in Fig. 3. Above 4% available CaO in the sludge there is a steady increase in the solids in the centrifuged liquor.

Effect of Activity on Clarity of Centrifuged Liquor

Assuming a constant green liquor concentration,

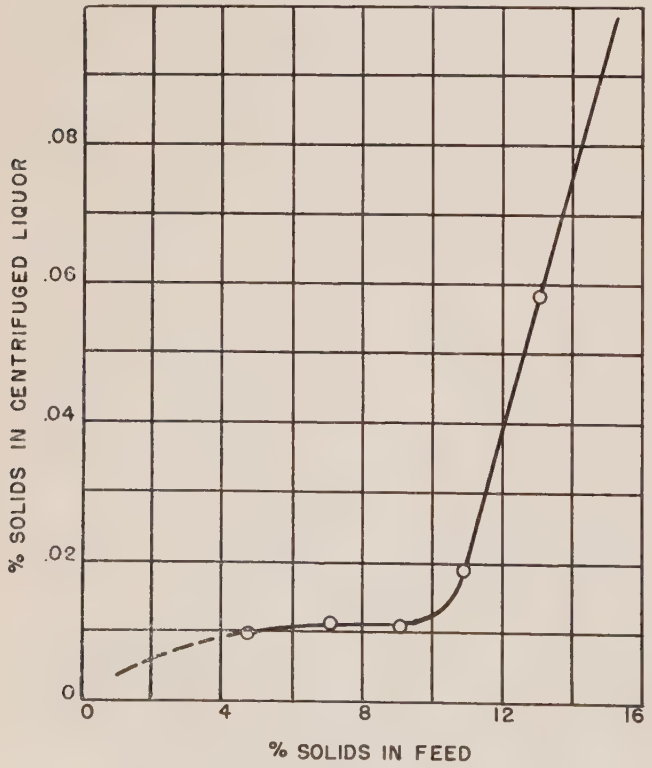

Fig. 5. Effect of per cent solids in feed on clarity of white liquor

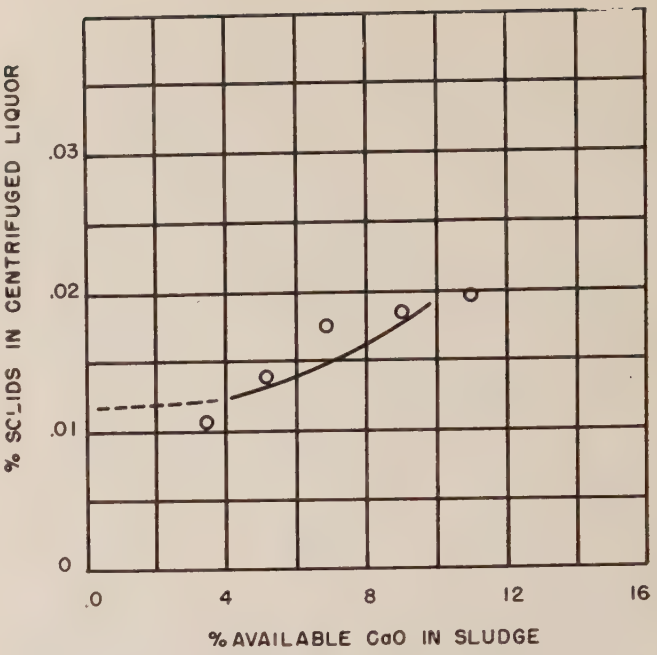

Fig. 6. Effect of CaO in sludge on clarity of white liquor

when the activity of white liquor is raised in mill operation it is frequently attended by slower settling rates. There are three factors entering into the character of the change: (1) the conversion of carbonate to hydroxide results in a decrease in density of the liquor, (2) the precipitated solids increase as the activity rises, and (3) frequently the sludge produced increases in available CaO. The effect of (1) is to speed up the clarification; the effect of (2) and (3) is to slow up the clarification.

The authors' experiments in centrifugal clarification indicate that if the solids content of the feed and the available CaO in the sludge remain within limits as

Table I. Effect of Activity on Clarity of Centrifuged Liquor

Activity	*Liquor rate, g.p.m.*	*Available, CaO*	*% Solids, feed*	*% Solids, centrifuged liquor*
80.2	9.32	1.44	8.98	0.0086
81.4	10.30	2.00	8.87	0.0083
83.5	9.12	1.54	9.29	0.0130
87.3	11.00	2.54	9.36	0.0083

indicated in above discussions, activity will have little or no effect on the clarity of the centrifuged liquor. This is indicated in Table I.

Clarification of Green Liquor

Before discussing the effect of green liquor solids on the clarity of white liquor, the following data are given on the centrifugal clarification of green liquor.

An attempt was made to clarify green liquor in the centrifugal using liquor from the storage tank ahead of the green liquor tray clarifier as feed. The liquor in the tank contained 0.0341% suspended solids at the time of the test. Results of these tests are given in Table II.

Table II. Centrifugal Clarification of Green Liquor

Feed rate, g.p.m.	*% Solids in feed*	*% Solids in clarified green liquor*
0.86	0.0341	0.0048
1.62	0.0341	0.0114
6.21	0.0341	0.0284

It can be seen that the liquor was not being satisfactorily clarified even at low feed rates and when the rate was increased to only 6.21 g.p.m., 83.3% of the solids remained in the liquor. It was concluded, therefore, that this type of centrifugal filter was not adaptable to green liquor clarification.

Effect of Green Liquor Solids on Clarity of White Liquor

During the operation of the centrifugal, it was noticed that at times the green liquor contained a fairly large amount of suspended solids. At these times the white liquor from the centrifugal become more turbid and the solids in the white liquor had the appearance of green liquor solids rather than that of calcium carbonate which constitutes most of the solids in white liquor from the tray clarifiers.

Since the per cent suspended solids are never very great in clarified green liquor it is obvious that the effect on the white liquor will not be as pronounced as a fluctuation in some of the other variables. In order to determine the effect of the green liquor solids on clarity of the white liquor, a sample of green liquor was taken just ahead of the slaker every hour during the continuous running period. These samples were analyzed for total suspended solids.

Using only those sets of data where the other variables were reasonably constant, the data were analyzed as explained in a previous section. The resulting curve is presented in Fig. 7. It is apparent that if green liquor solids are not removed before the liquor is causticized, they will not be efficiently removed in the centrifugal and will remain in the white liquor.

This is not the case in tray clarification of white liquor. In settling the green liquor solids are carried out in the sludge to a much larger extent than in centrifugal separation. This can be further substantiated by the analyses of solids filtered from the liquor samples. Analyses were made on solids filtered from the white liquor after the tray clarifiers, white liquor after the centrifugal, and green liquor. These analyses are given in Table III.

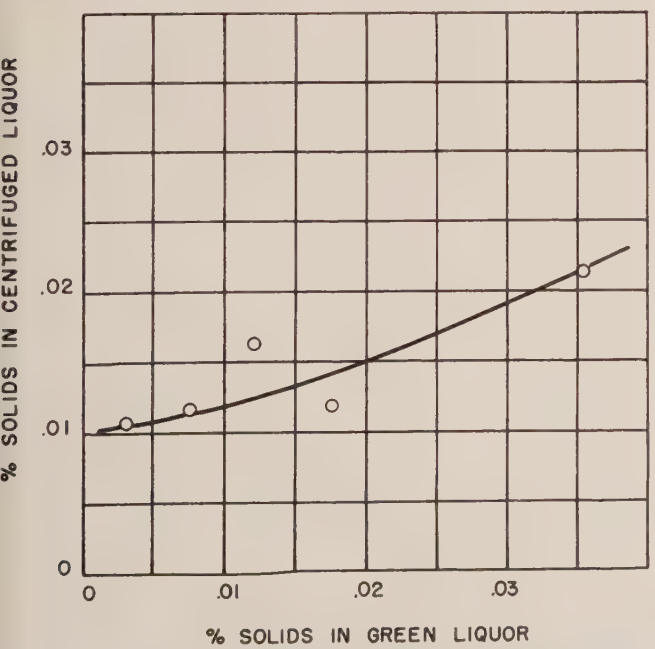

Fig. 7. Effect of solids in green liquor on clarity of white liquor

Table III. Chemical Analysis of Solids Filtered from Liquor Samples

	White liquor clarifiers	*White liquor centrifuge*	*Green liquor*
CaO	49.40	29.50	17.00
MgO	3.79	7.86	5.50
SiO_2	2.15	4.52	4.32
FeS	2.51	8.42	22.50
Na_2O	3.03	6.65	0.00
Organic (diff.)	7.62	18.95	18.80
CO_2	31.50	24.10	31.88

The green liquor solids were difficult to wash before analysis without affecting composition of the solids, so the results were calculated to a soda-free basis which puts them on a basis slightly different from the others. They show, however, that green liquor solids are characterized by high FeS content and low CaO content. The solids from the centrifuged white liquor are higher in FeS and much lower in CaO than those from tray clarified white liquor which, we believe, indicates that the green liquor solids are largely carried through the centrifugal into the liquor.

Comparison of White Liquor from Tray Clarifier with White Liquor from Centrifugal

On earlier studies to determine the per cent suspended solids in white liquor produced in clarifiers, it was found that the white liquor at the digester room contained a much lower solids content than the white liquor leaving the clarifiers. This was an advantage since it was desirable to have as little calcium as possible reach the digesters—the only disadvantage being that the sludge built up in the white liquor storage tanks and had to be cleaned out occasionally. Results of some of the tests follow:

Per Cent Suspended Solids in White Liquor	
At Clarifiers:	
Maximum	0.096
Minimum	0.00
Average 63 tests	0.0218
At Digesters—	
Maximum	0.0081
Minimum	0.00
Average 63 tests	0.0026

During the experimental runs the quality of the centrifuged white liquor was compared with that of the tray clarified white liquor and on the average the two liquors were about the same with respect to per cent suspended solids. To have the same quality when used, the centrifuged liquor would have to respond as readily to secondary clarification. Tests were conducted in the laboratory to determine the rate at which the suspended solids could be removed from the two liquors—employing settling alone. Results of one series of tests are given in Table IV.

It is apparent that the solids suspended in white liquor from the centrifugal filter will remain in the liquor much longer than the solids in liquor produced from tray clarifiers.

The cause of this difference in the two liquors can be explained by considering the difference in the two types of separation. The solids which remain in the liquor after tray settling agglomerate to a certain extent to form flocs which would settle out if given more time in the clarifier and which do settle out in storage.

The solids remaining in the centrifuged liquor, on the other hand, have been completely separated into the individual particles by the violent action of the centrifugal and the smaller particles are retained in the liquor. Since these are the slowest settling particles and since there are no large particles present to assist them in settling, they will remain in suspension a much longer period of time than the particles found in tray clarifier liquor.

Table IV. Settling of Solids in White Liquor

	Per cent Suspended solids remaining in liquor		*Solids remaining as per cent of original solids*	
Time, hr.	*From centrifugal*	*From clarifiers*	*From centrifugal*	*From clarifiers*
0	0.0186	0.0069	100.0	100.0
1	0.0181	0.0036	97.5	52.2
2	0.0174	....	93.6	....
3	0.0177	0.0020	95.2	29.0
5	0.0155	0.0018	83.5	26.1
7.25	0.0160	0.0009	85.8	13.1
25	0.0002	0.0000	1.1	0.0

The appearance of the two liquors will bear this out, also. In the case of liquor from the tray clarifier the solids appear to exist as large particles or clusters of particles. The liquor itself is clear and of a yellow to amber color. In the case of liquor from the centrifugals the solids are completely dispersed in the white liquor and although a laboratory test will show that suspended solids exist in the liquor, it is impossible to see the individual particles in suspension. They are completely broken up and dispersed through the liquor and give the liquor a green color and somewhat muddy appearance.

SUMMARY

Centrifugal clarification will produce a white liquor with suspended solids content equal to that found in white liquor from tray clarifiers.

Centrifugal separation is affected to a greater extent by the following factors: (1) rate of feed, (2) per cent solids in feed, (3) per cent available CaO in sludge, and (4) presence of green liquor solids.

Variation of activity over practical limits has no appreciable effect on the white liquor clarity.

Decrease in temperature has a strong detrimental effect on the white liquor clarity.

Solids remaining in centrifugal liquor settle with difficulty, those remaining in tray clarified liquor separate more easily.

Received Sept. 12, 1949. Presented at the Fall Meeting of the Technical Association of the Pulp & Paper Industry held at the Multnomah Hotel, Portland, Ore., Sept. 12–15, 1949.

The authors desire to express their appreciation to the Bird Machinery Co. for its whole hearted cooperation in supplying the centrifugals used in the above experimental work. They desire also to thank J. J. Gillis of the Bird organization for his assistance in conducting the tests. We are also appreciative of the constructive comments offered.

Acknowledgment is also made to the Gaylord Container Corp. for permission to publish the data contained in this report.

To those of their colleagues who spent so many long and late hours in accumulating the data the authors are very grateful.

Sulphate Pulping of Logging and Sawmill Wastes of Old-Growth Douglas Fir and of Certain Associated Species

J. S. MARTIN

Samples of Douglas fir of a lower quality than desired for lumber were obtained from the vicinity of Oakridge, Ore., and made into sulphate pulp at the Forest Products Laboratory. The samples included rough sound wood from suppressed trees, both old- and young-growth, and portions of old-growth wood infected with white pocket. Wood of equal density and chemical composition but with three stages of decay were pulped: (1) stained wood with incipient decay; (2) firm or intermediate rot; and (3) advanced rot. Sulphate pulping tests were also made individually on sound mountain hemlock, noble fir, and lodgepole pine, which are associated with the Douglas fir, and on a naturally occurring mixture of these species with Douglas fir. Douglas fir and associated species were all pulped satisfactorily by the sulphate process with chemical requirements comparable with those of present mill practice. The pulps made from wood containing incipient, firm, and advanced rot were equal in yield and had a lower bleach requirement than pulps made from the sound wood. The results obtained indicate that the following strength properties might be expected in strong sulphate pulps made from the various woods: (1) Pulp made from sound old-growth Douglas fir wood might be slightly lower in bursting strength and significantly higher in tearing strength than southern pine sulphate pulp and probably could be expected to be used for purposes now served by southern pine pulp except where maximum bursting strength or a fine-fibered pulp are needed. (2) Sulphate pulps made from Douglas fir wood containing decay will be lower in bursting strength than those from sound wood in proportion to the amount and type of decay. The bursting strength of the pulp made from wood containing advanced rot would probably be about 75% of that of southern pine pulp. (3) Mountain hemlock, noble fir, and lodgepole pine will give pulps with excellent bursting strength and fair tearing strength. (4) Sulphate pulp made from a mixture of 70% Douglas fir, 10% mountain hemlock, 10% noble fir, and 10% lodgepole pine would have a good bursting strength and excellent tearing strength and be of higher quality than pulp made entirely from sound Douglas fir. (5) Pulp of the quality of that obtained from sound Douglas fir would be produced from compositions of wood in which either 2.6 parts of wood with incipient decay, 1.7 parts of wood with firm rot, or 1.2 parts of wood with advanced rot are mixed with 1 part of any of the associated species, mountain hemlock, noble fir, and lodgepole pine. Because of the packing characteristics of the chips, the lower moisture content of the several types of decayed Douglas fir as compared to that of the sound wood would tend to cause a lower pulp production rate and require an adjustment of the chemical charge in the digester.

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THE EXPERIMENTS described in this report were made for the purpose of determining the suitability of sound (but defective for lumber manufacture) and decayed old-growth Douglas fir (*Pseudotsuga taxifolia*), mountain hemlock (*Tsuga mertensiana*), noble fir (*Abies procera*), and lodgepole pine (*Pinus contorta* var. *latifolia*) logging and sawmill waste from Oakridge, Ore., for the production of kraft pulps.

In the Douglas fir region of Oregon there exists a vast amount of defective old-growth wood with little or no lumber value, and waste wood remaining on the ground in cull material after a logging operation amounting to around 19 cords per acre in some instances. An even larger amount of wood waste is the old-growth Douglas fir with varying degrees of white pocket. The decay organism, *Fomes pini*, attacks the heartwood portion of the standing tree causing a red heart rot, better known as white pocket. Profitable utilization of these waste materials is necessary to obtain maximum returns from extensive forest stands of this type.

A pulping trial was also made on a sample of extremely decayed Douglas fir log centers.

In the evaluation of the wood and pulps, all tests and procedures were made according to standard methods of the Technical Association of the Pulp and Paper Industry or those of the Forest Products Laboratory.

THE WOOD

The wood was received in the form of rough round logs either 4 or 8 feet in length. John B. Grantham of Oregon State College and J. A. Hall, E. E. Matson, and E. G. Locke of the Pacific Northwest Forest and Range Experiment Station assisted in the selection and marking of the sample logs.

The samples of Douglas fir wood used in the pulping experiments included two types of sound material and four types of infected wood in different stages of decay with white pocket. These six types of Douglas fir are identified and described as follows:

Lot 1 consisted of small young-growth wood and large old-growth material known as yellow fir. These logs were considered typical of sound, clear wood from small depressed trees and from rough tops from old-growth trees.

Lot 2 consisted of incipiently decayed and stained wood taken from the central areas of defective and culled Douglas fir.

Lot 3 consisted of firm but partly rotted wood infected with *Fomes pini* taken from the central areas of culled Douglas fir. This type of material had formerly been used for the production of number 4 common lumber.

Lot 4 contained wood taken from the central areas of the logs in an advanced decayed condition with only a small amount of wood with firm rot.

The designation of lot 5 was given to a sample of Douglas fir received previously to the main shipment. This sample was extremely decayed with white pocket, of honeycomb appearance, and much lower in density than the other lots of decayed wood.

The designation of lot 1A was assigned to wood taken from the rim surrounding the decayed areas of the logs from which lots 2, 3, and 4 were obtained. The material in the rim areas was considered to be sound wood, but because it was closely associated with decayed portions in the logs the rim area wood was pulped separately from the sound wood of lot 1.

WOOD EVALUATION

Preparation of the Wood

Disks 1 inch in thickness were cut from the center of the 8-foot logs and from near the end of the 4-foot pieces for physical tests. The remaining 4-foot lengths were cut to a size to fit the Laboratory chipper. The Douglas fir logs containing decay were cut in such a manner that pieces of chipper size could be segregated according to lot number and the type of decay previously designated.

The wood of each species was chipped and screened to obtain a quantity of chips nominally $^5/_8$ of an inch in length. A representative sample of the chips from each species was taken for chemical analysis.

Physical Tests on Douglas Fir Wood

The growth and physical test data obtained from sample disks of the several lots of sound and decayed Douglas fir are recorded in Table I.

The data show that the sound Douglas fir (lot 1) contained both young- and old-growth groups of logs. The young-growth wood, with an average age of 90 years, consisted of the smaller logs averaging 7.5 inches in diameter inside the bark, whereas the old-growth wood, with an average age of 223 years, consisted of larger logs averaging 17 inches in diameter.

The portions of the logs used to represent material with various degrees of decay were all heartwood and contained no sound wood. However, the whole logs

Table I. Growth and Physical Characteristics of Sound and Decayed Douglas Fir Logging Waste

Wood							Heartwood			
Description of sample	*Shipment No.*	*Lot No.*	*Volume of decayed portion of log, %*	*Average diameter, in.*	*Average age, yr.*	*Average growth rate, rings per in.*	*Average diameter, in.*	*By volume, %*	*Bark by weight (dry basis), %*	*Density (moisture-free weight and green volume), lb. per cu. ft.*
Rough sound wood (8 small logs)	2655	1	0	7.5	90	24.4	5.8	58.2	10.9	30.1
Rough sound wood (4 large logs)	2655	1	0	17.0	223	26.6	14.2	71.0	19.3	26.2
Average (weighted) for sound wood	2655	1	0	10.7	134	25.1	8.6	67.3	14.1	27.4
Sound wood from lots 2, 3, 4	2655	1A	0	..	..	42.7	..	60	..	28.6
Incipient rot (Whole logs)			52.2	30.7	286	18.6	27.4	79.6		..
(Decayed portion of logs)	2655	2	..	22.2	137	12.0	..	100.0	..	27.1
Intermediate or firm rot (Whole logs)			56.1	31.2	322	20.7	28.2	82.3		
(Decayed portion of logs)	2655	3	..	23.2	176	14.3	..	100.0	..	28.6
Advanced rot (Whole logs)			66.8	25.3	279	22.4	23.6	87.8		..
(Decayed portion of logs)	2655	4	..	19.6	180	18.3	..	100.0	..	26.4
Centers of extremely decayed logs	2666	5	100.0	..	..	..	..	..	..	14.7

Table II. Chemical Analyses of Sound and Decayed Douglas Fir Logging Waste

Wood: Description of sample	Shipment No.	Lot No.	Cellulose: Holocellulose, %	Cellulose: Alpha in holocellulose, %	Lignin, %	Pentosans: Total, %	Pentosans: In holocellulose, %[a]	Solubility in: Alcohol-benzene, %	Solubility in: Ethyl ether, %	Solubility in: 1 per cent NaOH %	Hot water, %	Ash, %
Sound wood (average all logs)	2655	1	67.0	50.4	27.2	6.8	7.9	4.4	1.2	15.1	5.6	0.2
Sound wood surrounding decayed areas of lots 2, 3, 4	2655	1A	62.5	48.0	27.6	4.8	4.7	4.4	2.0	12.4	4.1	0.3
Incipient rot (decayed portion of log)	2655	2	62.6	47.6	27.8	5.0	5.7	4.2	2.4	14.2	2.2	0.1
Intermediate rot (decayed portion of log)	2655	3	63.0	48.4	28.5	4.8	5.6	3.6	1.4	14.3	3.3	0.2
Advanced rot (decayed portion of log)	2655	4	64.3	49.0	27.7	4.9	4.8	3.9	1.4	14.1	4.0	0.1
Centers of extremely decayed logs	2666	5	67.9	43.1	24.8	6.1	7.1	3.7	0.8	20.0	5.6	0.1

[a] Results based on holocellulose; all other values are based on moisture-free wood.

had decayed portions by volume of 52.2% for logs containing incipient rot, 56.1% for firm rot, and 66.8% for advanced rot. The densities of the samples containing the incipient, firm, and advanced rots were similar to that of the sound wood (lot 1).

When pulped, the moisture content of each type of decayed wood was much lower than that of either lot of sound wood. Since dry chips pack less densely than moist chips, the drier condition of the decayed parts of the logs would reduce the amount of chips that could be charged into a digester and thereby lower the amount of pulp obtained per digestion.

Chemical Tests on Sound and Decayed Douglas Fir

The data in Table II on the chemical analysis of Douglas fir wood indicate that the sound wood surrounding infected areas (lot 1A) and the woods containing incipient, firm, and advanced rots all had essentially the same chemical composition, but they all had definitely lower holocellulose and pentosan contents and a little lower alpha-cellulose content than the sound wood of lot 1. Judged by the chemical composition and the density values of these samples, the extent of the deterioration was less than that indicated by visual examination and less than that required to interfere with normal reactions with sulphate cooking liquors.

Physical Tests on Mountain Hemlock, Noble Fir, and Lodgepole Pine

The growth and physical tests obtained from the sample disks of mountain hemlock, noble fir, and lodgepole pine are given in Table III.

The points of interest about the samples of wood examined were (1) the small diameter and the rather high value for the average rings per inch of growth indicated a suppressed type of wood, (2) the low amount of bark for the lodgepole pine and the high amounts for the mountain hemlock and noble fir, and (3) the slightly higher than normal density of the lodgepole pine. The density values are important factors in the yield of pulp obtainable from a unit volume of wood and in the weight of chips that can be charged to a digester.

The weight of moisture-free wood in a 128-cubic foot cord of 4-foot rough logs for the noble fir was only 70% of that for the lodgepole pine, as shown in the following tabulation:

	Noble fir	Lodgepole pine
Per cord of rough logs:		
Weight of dry wood, lb.	1755	2520
Solid volume of wood, cu. ft.	79	92
Number of logs	35	55

Chemical Tests on Mountain Hemlock, Noble Fir, and Lodgepole Pine

The chemical analysis data for mountain hemlock, noble fir, and lodgepole pine are given in Table IV.

The three species had much lower holocellulose and alpha-cellulose contents than did the sound Douglas fir. From the standpoint of pulping, any advantage gained by the small amount of extractive material in noble fir would be offset by the disadvantage of the high lignin content of the wood.

SULPHATE PULPING

Preparation and Testing of the Pulps

Sulphate pulping experiments were made to produce strong sulphate or kraft-type pulps. For the determination of the yield and strength properties of the pulps portions of the chips equivalent to 4 pounds of moisture-free wood were cooked in 0.5-cubic foot, steam-jacketed, rotary spherical autoclaves heated indirectly with steam. In all the digestions the cooking schedule consisted of a 1.5-hour temperature increase period from room temperature to the maximum temperature of 170°C. (100 pounds gage pressure) and a 1.5 hour cooking period at that temperature. No spent (black) liquor was used in any of the digestions. Calculations of volumes and chemical concentrations of the cooking liquors included the moisture in the chips. Cooking liquors for all digestions had a sulphidity of 30% based on the active alkali (sodium hydroxide plus sodium sulphide both calculated as sodium oxide) present.

After completion of the digestions, the pulped chips

Table III. Growth and Physical Characteristics of Mountain Hemlock, Noble Fir, and Lodgepole Pine

Wood: Species	Shipment No.	Average diameter, in.	Average age, yr.	Average growth rate, rings per inch	Heartwood: Average diameter, in.	Heartwood: By volume, %	Bark by weight (dry basis), %	Density (moisture-free weight and green volume), lb. per cu. ft.
Mountain hemlock	2656	10.2	164	33.5	5.9	38.2	18.3	25.6
Noble fir	2657	9.1	135	30.8	4.6	36.0	26.7	22.2
Lodgepole pine	2658	8.1	159	39.2	6.3	63.7	5.4	27.4

Table IV. Chemical Analyses of Mountain Hemlock, Noble Fir, and Lodgepole Pine

Wood: Species	Shipment No.	Cellulose: Holocellulose, %	Cellulose: Alpha in holocellulose, %	Lignin, %	Pentosans: Total, %	Pentosans: In holocellulose, %[a]	Solubility in: Alcohol-benzene, %	Solubility in: Ethyl ether, %	Solubility in: 1 Per cent NaOH, %	Solubility in: Hot water, %	Ash, %
Mountain hemlock	2656	59.8	42.6	27.0	7.0	7.4	4.6	1.0	11.6	4.8	0.5
Noble fir	2657	61.3	42.8	29.3	9.0	9.2	2.7	0.6	9.6	2.3	0.4
Lodgepole pine	2658	63.2	43.8	25.0	9.2	8.8	3.5	2.3	12.6	3.6	0.2

[a] Results based on holocellulose; all other values are based on moisture-free wood.

from the autoclaves were broken up, thoroughly washed, screened through a 12-cut (0.012-inch slot width) flat screen, pressed to approximately 33% dryness, and sampled for moisture. The pulp yields were calculated on a moisture-free basis.

Sulphate Pulping Conditions

Preliminary pulping experiments were made on the sound Douglas fir wood (lot 1) to establish the optimum conditions with respect to chemical-wood ratio, sulphidity, and liquor-wood ratio. The optimum conditions arrived at are given in Table V. These conditions gave the highest screened yield and pulp strength. The other types of Douglas fir (and the other species) were pulped under these optimum cooking conditions for the sound Douglas fir wood. The chemical requirement of 15.6% Na_2O or 646 pounds of Na_2O per ton of air-dry pulp for these kraft pulps is in line with present mill practice.

Effect of Degree of Decay

Tables V, VI, and VII show the results of pulping under the same cooking conditions sound Douglas fir and wood decayed to different degrees by *Fomes pini*. The results indicate that the decayed wood can be satisfactorily reduced to pulp under the same conditions as are required for sound wood. Nearly the same yields of pulps on a weight basis were obtained for all the types of Douglas fir. The yields of pulp ranged from 43.5% for the sound wood of lot 1 to 45.1 for the wood with incipient decay. These yield values are equal to or slightly higher than those reported by Wilkie (*1*) who obtained yields of only 38 to 40% from decayed wood; 41 to 43% from sound, old-growth material; and 44 to 46% from second-growth Douglas fir. As measured by the bleach test data and the permanganate number, the pulps from wood with incipient, intermediate, and advanced decay would appear to be easier to bleach than the two types of sound wood.

The moisture contents of the freshly chipped wood were much lower for the several lots of decayed wood (22 to 23%) than for two lots of sound material (33 to 38%). Since the results indicate that the decayed wood can be reduced under the same conditions as are required for sound wood, it appears that the only changes necessary for satisfactory pulping of the lower-moisture-content decayed wood would be in the proper adjustment of the chemical charge to compensate for the decreased amount of wood substance in the digester. This adjustment is necessary so as not to overcook the decayed wood to the detriment of pulp yield and quality.

The chemical composition of the various types of Douglas fir pulps show that the pulp from decayed wood was considerably higher in alpha-cellulose and lower in lignin and pentosan contents than the pulps from sound wood (lot 1). The high ratio of alpha-cellulose to pentosan contents in the kraft pulps from infected Douglas fir is much closer to that required in rayon-grade pulps than is usually found in kraft pulps from the sound wood of most pulpwood species.

The bursting strength was the highest for the pulps made from the sound wood (lot 1) and decreased with increasing degree of decay. The pulps from both the sound wood surrounding decayed areas (lot 1A) and the material with incipient decay (lot 2) had approximately the same bursting strength. The tensile strength also tended to decrease but the folding endurance showed no definite trend with increase in the

Table V. Sulphate Pulping of Sound and Decayed Douglas Fir, Mountain Hemlock, Noble Fir, Lodgepole Pine, and a Mixture of These Species

Wood: Species	Wood: Description	Wood: Lot No.	Wood: Moisture content, %	Digestion No.	Cooking[a] and yield data: Chemical consumed, %	Cooking[a] and yield data: Black liquor density at 15°C., °B.	Cooking[a] and yield data: Yield of pulp (moisture-free): Per 100 pounds of moisture-free wood: Screened, lb.	Cooking[a] and yield data: Yield of pulp (moisture-free): Per 100 pounds of moisture-free wood: Screenings, lb.	Cooking[a] and yield data: Yield of pulp (moisture-free): Per cubic foot of solid wood (screened pulp) lb.	Bleach test data: Brightness Pulp bleached with 8.75% chlorine, %	Bleach test data: Permanganate No.
Douglas fir	Sound (entire logs)	1	37.9	1936, 1937	85.5	11.1	43.5	1.4	11.9	29.4	29.7
Douglas fir	Sound (outside rim)	1A	33.2	1964, 1965	84.1	11.0	44.6	1.2	12.8	29.4	25.9
Douglas fir	Incipient decay	2	22.4	1962, 1963	83.9	11.1	45.1	0.9	12.2	35.2	24.0
Douglas fir	Firm rot	3	23.2	1954, 1955	86.9	11.0	44.7	0.8	12.8	31.7	22.3
Douglas fir	Advanced rot	4	23.1	1951, 1952	87.4	11.0	44.9	0.8	11.9	33.1	22.5
Douglas fir	Extreme rot	5	15.7	1934, 1935	90.4	10.8	41.8	1.1	6.1	27.9	29.4
Mountain hemlock	Sound	...	48.6	1966, 1967	81.8	11.0	45.0	1.1	11.5	30.9	29.1
Noble fir	Sound	...	54.1	1997, 1998	80.4	10.7	47.2	0.4	10.5	36.1	28.8
Lodgepole pine	Sound	...	45.6	1974, 1975	81.8	10.7	45.8	0.8	12.5	40.4	24.7
Species mixture	...	...	33.7	2003X, 2004X	83.4	10.9	45.9	1.1	...	35.0	26.9

[a] The cooking conditions other than those outlined are as follows:
Chemicals charged per 100 pounds of moisture-free wood:
Sodium hydroxide and sodium sulfide, lb..... 20.0
Calculated as sodium oxide, lb..... 15.6
Initial chemical concentration, g./l..... 39.1
Sulphidity (based on active alkali), %..... 30.0
Liquor-wood ratio..... 4.0

Table VI. Strength of Sulphate Pulps from Sound and Decayed Douglas Fir, Mountain Hemlock, Noble Fir, Lodgepole Pine, a Mixture of These Species and Southern Pine

Wood: Species	Wood: Description	Lot No.	Digestion No.	Interpolated test-beater strength data on unbleached pulp[a]: Bursting strength, freeness, ml.[b] 450 pt. per lb. per rm.	Bursting strength, freeness, ml.[b] 250 pt. per lb. per rm.	Tearing strength, freeness, ml.[b] 450 g. per lb. per rm.	Tearing strength, freeness, ml.[b] 250 g. per lb. per rm.	Tensile strength, breaking length, freeness, ml.[b] 450 meters	Tensile strength, breaking length, freeness, ml.[b] 250 meters	Folding endurance, freeness, ml.[b] 450 double folds	Folding endurance, freeness, ml.[b] 250 double folds
Douglas fir	Sound (entire logs)	1	1936, 1937	1.24	1.30	2.48	2.38	7,400	8,300	1325	1550
Douglas fir	Sound (outside rim)	1A	1964, 1965	1.14	1.18	3.90	2.87	6,700	7,600	1425	1625
Douglas fir	Incipient decay	2	1962, 1963	1.13	1.22	4.18	3.17	6,300	7,100	1500	2000
Douglas fir	Firm rot	3	1954, 1955	1.05	1.11	3.43	2.87	6,300	6,900	1550	2100
Douglas fir	Advanced rot	4	1951, 1952	0.97	1.09	3.80	3.32	5,700	7,200	925	1550
Douglas fir	Extreme rot	5	1934, 1935	0.95	1.07	1.85	1.75	6,800	7,600	875	1300
Mountain hemlock	Sound	...	1966, 1967	1.54	1.66	1.53	1.33	9,200	9,200	2580	2450
Noble fir	Sound	...	1997, 1998	1.55	1.76	1.85	1.51	10,400	11,100	2100	2600
Lodgepole pine	Sound	...	1974, 1975	1.56	1.66	1.72	1.44	8,800	9,400	1800	3400
Species mixture	...	...	2003X, 2004X	1.37	1.52	2.83	2.40	8,600	9,300	980	1200
Southern pine	...	...	9057-T[c]	1.17	1.25	2.00	1.70	...	...	650	800

[a] Test sheets conditioned and tested at 23°C. and 50% relative humidity; ream weight of 55 pounds (25 × 40—500).
[b] Canadian Standard.
[c] Commercial southern pine unbleached kraft pulp.

amount of decay in the wood. The tearing strengths of the pulps from the sound wood surrounding decayed areas (lot 1A) and from the three lots of decayed material were as high as would be normally expected from sound old-growth Douglas fir pulpwood and were much higher than those from the sound wood (lot 1). Unfortunately, outstanding tearing strength in a pulp will not offset a low bursting strength when it is judged for quality.

The data indicate that a sulphate pulp from the sound Douglas fir is slightly lower in bursting strength and significantly higher in tearing strength than southern pine sulphate pulp. It would be expected that the commercial use of this kind of Douglas fir pulp would be comparable to that of southern pine sulphate pulp. It would not be so useful where high bursting strength or a fine-fibered pulp are needed.

The relative strength properties of the sulphate pulps made from the sound and decayed Douglas fir and from mixtures of these pulps with those from the other species are discussed later in this report.

Sulphate Pulping of Mountain Hemlock, Noble Fir, and Lodgepole Pine

The pulping tests on mountain hemlock, noble fir, and lodgepole pine consisted of cooking each species under the same cooking conditions as those used for the production of kraft pulps from Douglas fir. The data for the pulps are also given in Tables V, VI, VII. Preliminary tests on these woods had indicated that, like Douglas fir, 15.6% active alkali as Na_2O was sufficient for their satisfactory reduction. When produced under the same cooking conditions, the yields of screened kraft pulp from mountain hemlock and lodgepole pine were nearly the same as those from infected Douglas fir. Under comparable cooking conditions, noble fir gave the highest yield on a weight basis, 47.2%, but, because of its rather low density of 22.2 pounds per cubic foot, the lowest yield of pulp on a volume basis of all the materials tested.

The three species gave pulps with excellent bursting and tensile strengths and fairly good tearing strength. The bursting strength of each of these pulps was about equal to that from western hemlock and higher than that from southern pine.

The chemical composition of the pulps made from mountain hemlock, noble fir, and lodgepole pine were normal for the cooking conditions used. The lower lignin contents and permanganate numbers for the pulps made from lodgepole pine as compared to those made from mountain hemlock and noble fir indicate lower bleach requirements for the lodgepole pine but not so low as for pulps made from decayed Douglas fir.

Sulphate Pulping of a Mixture of Species

The following mixture of species was made up to stimulate that occurring naturally in stands in the Oakridge area:

Wood	Per cent (by weight)
Douglas fir, lot 1	25
Douglas fir, lot 1A	25
Douglas fir, lot 2	10
Douglas fir, lot 3	5
Douglas fir, lot 4	5
Mountain hemlock	10
Noble fir	10
Lodgepole pine	10

The mixture was pulped with the same amount of

Table VII. Chemical Analyses of Unbleached Sulphate Pulps Prepared under the Same Cooking Conditions from Sound and Decayed Douglas Fir, Mountain Hemlock, Noble Fir, Lodgepole Pine and a Mixture of These Species

Digestion No.	Wood: Species	Wood: Lot No.	Holocellulose, %	Alpha-cellulose, %	Lignin, %	Total pentosans, %
1936, 1937	Douglas fir	1	91.9	77.1	7.7	7.2
1964, 1965	Douglas fir	1A	95.3	83.3	5.2	5.0
1962, 1963	Douglas fir	2	98.0	87.7	4.2	4.6
1954, 1955	Douglas fir	3	95.7	87.5	4.4	4.3
1951, 1952	Douglas fir	4	95.3	87.1	5.3	4.5
1934, 1935	Douglas fir	5	92.7	78.6	6.8	5.7
1966, 1967	Mountain hemlock	...	93.7	77.2	6.2	7.3
1997, 1998	Noble fir	...	94.2	82.1	6.1	9.0
1974, 1975	Lodgepole pine	...	94.5	78.5	4.9	9.4
2003X, 2004X	Species mixture	...	93.4	79.8	5.8	6.6

cooking chemicals as that used for the individual species. The yield of screened pulp of 45.9% on a weight basis for the mixture was not appreciably different from the value of 44.8% calculated from the yields obtained from the individual woods.

The chemical composition of the pulp made from the mixture reflected the effects of the various proportions of the materials in its make-up. In this case, the ratio of alpha-cellulose to pentosan material was lower for the mixture than that for pulps made from the decayed Douglas fir.

The strength properties of the pulps were also proportionately commensurate with those of pulps prepared from the different woods used in the mixture. The pulp from the mixture had a good bursting strength and excellent tearing strength. It combined the good qualities of the different species to make what should be a very acceptable pulp.

Sulphate Pulping of a Special Sample of Extremely Decayed Douglas Fir Wood

The sample of extremely decayed Douglas fir (lot 5) was honeycombed and contained a fairly uniform distribution of the white pocket caused by *Fomes pini*. Its low density of 14.7 pounds per cubic foot was about one-half that of the other Douglas fir samples tested. As further evidence of its deterioration, the chemical analysis showed a high alkali solubility and losses of alpha-cellulose and lignin almost in proportion to the amount of their occurrence in the sound wood.

This wood was pulped under the same cooking conditions as those used for comparing the other decayed woods (Table V). The yield of 41.8% screened pulp obtained on a weight basis was only 4% lower than that obtained from the sound material and 7% lower than those obtained from the other decayed woods. However, owing to its low density the yield expressed on a volume basis of 6.1 pounds per cubic foot of solid wood was 50% less than that of the sound material and of the wood with advanced rot.

The pulp made from the extremely decayed wood was much closer in chemical composition to the pulp made from sound wood than to those made from the other decayed woods (Table VII).

The pulp made from the extremely decayed wood (lot 5) was (a) equal in bursting strength to that made from wood with advanced decay (lot 4), (b) definitely lower in tearing strength than any of the other Douglas fir pulps, (c) intermediate in tensile strength between that of pulps made from sound and decayed Douglas fir and equal to that of the pulp from the sound wood surrounding decayed areas (lot 1A). On the basis of bursting and tearing strength values, the strength of the pulps made from the sample of extremely decayed Douglas fir was about 75% of that made from the sound wood of lot 1, indicating that this kind of wood might be used where high bursting and tearing strengths were not greatly important. This type of material would, of course, be very difficult to handle in the wood room of a pulp mill.

COMPARISON OF PULPS

The strength properties of the sulphate pulps made from the various woods were adjusted for a 10% loss in strength to account for possible differences between experimental and commercial values and compared with a commercial southern pine pulp on a percentage basis. The results are shown in Table VIII.

Table VIII. Comparison of Strength of the Experimental Pulps with Commercial Southern Pine Sulphate Pulps

Kind of sulphate pulp	*Bursting strength, %*	*Tearing strength, %*
Southern pine	100	100
Douglas fir:		
Sound wood from lot 1	95	120
Wood surrounding decayed areas, lot 1A	85	165
Stained wood with incipient rot, lot 2	85	180
Wood with firm rot, lot 3	80	155
Wood with advanced rot, lot 4	75	175
Mountain hemlock	120	70
Noble fir	120	80
Lodgepole pine	120	75
Mixture of species	105	125

Sulphate pulps made from Douglas fir wood containing decay were lower in bursting strength than those made from the sound wood in proportion to the amount and type of decay. However, a considerable amount of decayed wood can be present in the Douglas fir and the lowered strength obtained in the sulphate pulp compensated for by mixing the wood with certain proportions of the associated species (mountain hemlock, noble fir, and lodgepole pine). For example, the reduction in quality caused by the presence of 2.6 parts of wood with incipient decay, 1.7 parts of wood with firm or intermediate decay, or 1.2 parts of wood with advanced decay in the Douglas fir can be restored by the addition of 1 part of any of the associated species. Therefore, the following compositions of decayed Douglas fir and associated species will produce sulphate pulp equivalent in quality to that obtained from sound Douglas fir:

(a) 55% advanced-decay Douglas fir (lot 4) and 45% associated species.
(b) 63% firm-decay Douglas fir (lot 3) and 37% associated species.
(c) 72% incipient-decay Douglas fir (lot 2) and 28% associated species.

A possible composition containing decayed wood and a minimum amount of the associated species that would produce a sulphate pulp having the same quality as one made entirely from sound Douglas fir might be made up of 65% sound wood, 25% incipient-decayed wood, and 10% associated species.

The sulphate pulp made from the mixture of species compounded in the proportions in which they naturally occur was of higher quality than that made entirely from sound Douglas fir because of the presence of a higher amount of the associated species. This mixture gave results which compared very favorably with the southern pine sulphate pulp.

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Received Aug. 17, 1949. Presented at the Fall Meeting of the Technical Association of the Pulp & Paper Industry, Multnomah Hotel, Portland, Ore., Sept. 11–15, 1949.

Acknowledgment is made to the late Mark W. Bray, Chemist, Forest Products Laboratory, under whose supervision most of this work was done. Acknowledgment is also made to Pope & Talbot, Inc., Portland, Ore., for their cooperation in this work.

Evaluation of the Biochemical Oxygen Demand in Streams

F. W. KITTRELL

Biochemical oxygen demand (B.O.D.) and dissolved oxygen (D.O.) determinations reveal the condition of polluted streams and are useful in predicting results of reduced waste discharge. An idealized example of the method of using these tools is presented. Practical difficulties met in application to stream examination and evaluation, due to numerous variables in natural streams, and suggestions for minimizing them, are described. These difficulties, imperfect understanding of the fundamentals involved, and a tendency to apply generally accepted concepts indiscriminantly to all types of streams, have combined to discredit the method. Recent developments, which provide explanations for past unsatisfactory experiences and give promise of more acceptable results in the future, are described. Pending further development, it is suggested that empirical rather than theoretical methods of interpreting B.O.D. and D.O. data may be utilized.

Dissolved oxygen (D.O.) of stream water is the constituent most frequently determined in observing the effect of organic pollution on streams. This alone provides an adequate check on existing conditions. If it is necessary to predict changes in stream conditions that will follow proposed reductions in plant wastes, the biochemical oxygen demand (B.O.D.) determination must be used as an adjunct to the D.O. determination.

The B.O.D. determination probably is the most misunderstood and the most abused of all the analytical tools used for examining stream conditions. In its present stage of development it is admittedly, an imperfect tool. Many of its apparent idiosyncrasies are chargeable to imperfect knowledge of some of the fundamental reactions involved rather than to inherent imperfections of the method itself. Although the inconsistencies of its biological reactions compel acceptance of results that may vary within 20%, it is not believed that it can be replaced by any of the chemical oxidation methods that have been proposed. No known chemical method can approximate the biological reactions that occur in a polluted stream. It is anticipated that present and future investigations of fundamentals will increase knowledge of the reaction that will assure its unquestioned acceptance for general use and that ability to interpret its hidden meanings no longer will be restricted to those experts who have devoted their lives to understanding its mysteries. It is easy to understand and sympathize, however, with that sanitary engineer who complained that at least one-half of each report on stream pollution that he prepared must be devoted to explaining away the results of faithfully determined and recorded B.O.D. results.

The B.O.D. reaction, with its monomolecular rate in both laboratory bottles and streams, which utilizes and reduces D.O., and the mechanics of absorption of oxygen from the atmosphere by water, are subjects that can be mastered with a little study. The typical oxygen sag curve, which results from these opposing forces, can be computed after certain factors characteristic of the stream and the pollution involved have been determined.

The basic theories first were evolved and formulated for polluted sections of the Ohio River (*1*) by the United States Public Health Service. Later Streeter (*2*) utilized the findings of these and subsequent experiences to present a discussion which probably is the most useful available for achieving an understanding of their application to stream conditions.

Since then other systems of stream evaluation have been evolved. Charts and graphs, such as those by Fair (*3*) and Velz (*4*), have been developed to minimize the tedious calculations involved. Phelps (*5*), who collaborated in the Ohio River studies, recently has published a book which is the most authoritative and comprehensive assemblage of basic knowledge of stream pollution available. All of these works have their foundations primarily in the concepts developed for the Ohio River.

It would be presumptuous to attempt to recapitulate the detailed theories and mathematics of these competent references in this article. It may be useful to illustrate their application by a simple example of a hypothetical stream survey and evaluation, and to discuss the possible implications of some of the more recent developments in this field.

In theory the survey and evaluation of a polluted stream is fairly simple, but in application many practical difficulties must be overcome to achieve dependable results. When these difficulties are not appreciated and met the results may be unsatisfactory, if not meaningless, and the natural reaction is to blame the B.O.D. determination.

For illustration, assume the simplest hypothetical case of stream pollution. A pulp and paper mill produces an absolutely uniform waste and discharges it continuously through a single sewer to an otherwise unpolluted stream, where complete mixing instantaneously occurs. Both the flow and channel of the receiving stream are uniform and no tributary streams enter the zone of pollution. The stream is swift enough to prevent settling of suspended solids to form sludge deposits. Finally, make the extremely important assumption that natural purification in this stream duplicates that observed in the Ohio River studies.

Under these ideal conditions the following procedure should yield the desired results:

1. Establish four sampling stations: (a) stream above waste discharge, (b) waste discharge, and (c) any two convenient points on stream below waste discharge.

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2. Measure flows: (a) stream and (b) waste.

3. Measure times of water travel: (a) stream from point of waste discharge to first downstream sampling station and (b) stream between downstream sampling stations.

4. Collect six to twelve sets of samples. (The somewhat erratic biological nature of the reactions involved requires sufficient samples to give statistically acceptable averages.)

5. Determine on all samples: (a) temperature, (b) D.O. (some samples should be collected at night to reveal whether photosynthetic activity of algae results in high daytime and low nighttime values), and (c) 5-day 20°C. B.O.D.

6. Analyze and interpret the data through application of Streeter's concepts: (a) convert average 5-day B.O.D. values to ultimate first stage B.O.D.; (b) convert first stage B.O.D. at 20°C. to first stage B.O.D. at stream temperature; (c) compute the B.O.D. reaction rate (designated the deoxygenation coefficient in the formulas) for the stream from the adjusted B.O.D. values at the two downstream stations and the time of water travel between; (d) convert average D.O. values to complementary oxygen deficiencies at stream temperature (amount of oxygen undersaturation); (e) compute rate at which oxygen is absorbed (reaeration coefficient) from the atmosphere, using data from the two downstream stations; (f) compute B.O.D. of stream at the point of waste discharge after mixture, convert to first stage and adjust for stream temperature; (g) compute D.O. deficiency of stream at the point of waste discharge after mixture, at stream temperature; (h) compute the time of water travel below the point of waste discharge (designated the critical time) at which the minimum D.O. value will occur, using B.O.D. and D.O. deficiency at point of waste discharge and deoxygenation and reaeration coefficients from downstream section; (i) compute the maximum B.O.D. concentration that the stream can tolerate at the point of waste discharge without depleting the D.O. at the minimum point below the desired value; (j) compute the B.O.D. in the plant waste that the stream can accept without excessive oxygen depletion; and (k) compute the needed reduction in B.O.D. of the plant waste to assure adequate D.O. in the receiving stream.

The further an actual stream departs from this ideal example the more complex is the problem of examination and evaluation. Waste discharge and flow of the receiving stream, which fix the concentration of waste in the stream at the instant the waste enters and mixes with the stream, are rarely uniform. The dilution ratio at a point of waste discharge may vary so frequently that none of the samples collected at several downstream points in a single day are correlative. Variations in stream flow alter times of water travel between fixed sampling points with corresponding variations in the reductions in B.O.D. that occur between the sampling stations. These irregularities, combined with variations inherent in the method of B.O.D. determination, necessitate large numbers of samples and accompanying records of stream flow to establish a representative record of stream conditions. Variations in channel characteristics are typical of all natural streams, and frequently the changes are both abrupt and extreme with corresponding changes in reaeration capacities. The reaeration capacity of even the same stream section varies with stream flow which affects turbulence. These variations necessitate the use of many sampling stations, bracketing the different types of stream sections, and numerous samples collected within each of several ranges of stream flow.

The Tennessee Valley Authority (*6*) has developed a method of stream sampling that compensates for some of the variables. This involves sampling the stream immediately below a point of waste discharge every 2 hours for a full 24-hour period, identifying the mass of water as it passes, and following it downstream to and sampling it for 24 hours at each of several downstream stations. This appears to give reasonably representative results with a short period of highly concentrated work, and has the additional advantage of automatically establishing times of water travel between stations.

It is rare that all wastes involved in a pollution study enter the stream through a single sewer. Frequently several towns and industries are spaced at intervals along the stream section and even a single town or industry may discharge wastes through several sewers. Tributary streams carrying additional pollution and providing dilution usually are involved. These factors complicate the mechanics of making stream studies and compound the difficulties of interpreting the data obtained.

Attempts to force the data obtained on all types of streams into the pattern developed for the Ohio River probably has been the single factor that has served, more than any other, to discredit the B.O.D. determination and its use in stream evaluation. This approach to interpretation of data simply does not work and the B.O.D. usually gets the blame. Recent developments are providing clues to the meaning of results that previously may have been considered faulty because of inherent inadequacies of the B.O.D. determination when actually only the understanding and interpretation of the results were at fault.

Accepted methods for formulating stream conditions require use of the ultimate first stage B.O.D., which is the theoretical B.O.D. at infinite time, rather than the determined 5-day value which is only an arbitrarily selected point on the B.O.D. curve. The 5-day B.O.D. usually is extended to first stage B.O.D. through application of the so-called standard rate of the reaction. The original development and general acceptance of this rate, which is designated as the deoxygenation coefficient with a numerical value of 0.1 at 20°C., is interesting. It originally was determined for sewage using the standard dilution method to obtain the necessary B.O.D. data. This method requires that any sample having a B.O.D. in excess of about 6 p.p.m. be diluted to avoid exhaustion of D.O. in the incubation bottle. The diluted samples on which the rate was developed therefore had low B.O.D. concentrations. It was coincidental that the B.O.D. concentrations of the stream samples in the Ohio River studies were in the same low range. Consequently it was found that the B.O.D. reaction rate

determined in the laboratory was approximately the same as that calculated for the river from the results of stream samples. This rate gained wide acceptance and use as the normal rate of first stage B.O.D. reactions in both laboratory and stream.

Scott (*7*), as early as 1936, questioned the universal application of this rate and subsequently proved that it varied rather widely even in the low range of B.O.D. concentrations required by the dilution method. More recently Caldwell and Langlier (*8*), and Kittrell and Kochtitzky (*6*) have reported data obtained on undiluted samples that indicate the rate may vary as a function of B.O.D. concentration. If this be true the B.O.D. rate must be determined at the concentration that occurs in each stream examined.

Both the deoxygenation coefficient and the first stage B.O.D. normally are adjusted for the differences between standard laboratory temperature and observed stream temperatures. Various investigators have reported different numerical factors for the deoxygenation coefficient conversion. Recently Gotaas (*9*) reported data on an unusually complete series of B.O.D. curves obtained at different temperatures which yielded still another deoxygenation coefficient conversion factor and indicated that first stage B.O.D. does not vary with temperature in the normal range of surface stream temperatures.

A generally accepted concept is that the rate of B.O.D. reaction in a stream is constant throughout a zone of natural purification in the absence of external interference. It is recognized that stream channel characteristics exert an important effect on reaeration rates, but their possible effect on the B.O.D. reaction rate has largely been either ignored or overlooked. Data recently reported (*6*) for a shallow, highly polluted stream indicate that the reaction rate is not constant but continuously diminishes as the polluted water flows downstream. These data suggest that the extremely rapid rate of B.O.D. reduction in this stream may have been due to absorption of organic matter in biological slimes on the bed of the stream that perform a function similar to that of a trickling filter. This implies that the stream channel characteristics may affect the rates of both reaeration and B.O.D. reduction.

Sludge deposits formed by suspended organic matter settling to the bottom of a stream complicate the computations of stream conditions. It can be shown mathematically that, after a sufficient period of relatively stable temperature and of waste and stream discharges, the accumulated sludge deposits should liberate oxygen demand daily that is essentially equivalent to the quantity of B.O.D. deposited daily by sedimentation. This hypothesis is the basis for the common practice of assuming that the effects of sludge deposits are compensating and can be ignored in calculating stream conditions. Fair, Moore, and Thomas (*10*) showed, in controlled laboratory experiments simulating stream conditions, that sludge deposits lose important portions of their organic content through liberation of unoxidized gases formed by anaerobic decomposition in the depths of the deposits. Under comparable stream conditions therefore, the oxygen demand liberated daily by sludge deposits can not be more than some presently indeterminate fraction of the daily deposition, and the assumption of compensating effects yields erroneous calculated results. The stream data reported by Kittrell and Kochtitzky (*6*) appeared to support the conclusions of Fair, et al, and indicated further that the same considerations may apply to organic matter stored in biological slimes on the stream bed.

This confession of limitations in present knowledge of the B.O.D. reaction in streams may be discouraging to those who already have little faith in the method. On the contrary it should be encouraging that recent investigations and findings indicate the profession is becoming increasingly aware of those limitations and is undertaking the research necessary to eliminate the causes for lack of faith.

Does this mean that practical use of the B.O.D. should be abandoned until the millenium arrives and all the fundamentals of the reaction are perfectly understood? By no means. After all, paper, and good paper at that, has been and is being made without complete understanding of all the intricate fundamentals of digesting, washing, bleaching, forming, and drying. Certain steps in the process still are controlled by rule of thumb and perhaps even by trial and error methods to produce an acceptable finished product.

The paper mill employee who is responsible for waste disposal need not concern himself unduly with an attempt to utilize a purely theoretical approach to interpretation of the data obtained on the stream below the plant. With a knowledge of the general principles involved and with a little ingenuity and common sense he can develop purely empirical relationships among the D.O., B.O.D., temperature, and flow data tailored to fit the local situation, which should provide all the information necessary for determining the approximate load the receiving stream can tolerate. In actual practice it is the rarest of circumstances that the plant management must know to the last decimal just how much reduction in waste ultimately will be necessary. A waste reduction program in an industrial plant rarely is completed as a single project. It proceeds, rather, as a series of projects which may require several years for completion. This affords an opportunity for testing and, if necessary, revising the empirical relationships as completion of each successive project and determination of its effects reveal the accuracy with which improvement in stream conditions was predicted for that particular project.

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Received Jan. 28, 1949. Presented at the Annual Meeting of the Technical Association of the Pulp & Paper Industry, Hotel Commodore, New York, N. Y., Feb. 21–24, 1949.

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DISCUSSION

Mr. Kittrell emphasizes two cardinal points in stream sanitation: the dissolved oxygen is the best single measure of organic pollution in streams and, notwithstanding vagaries and complexities of biochemical oxygen demand, D.O. and B.O.D. criteria should be applied to the practical problem of determining what degree of waste treatment is required to produce a desired stream condition. If we wait until the theorists nail down every vagary of B.O.D. before we apply our knowledge, we shall never arrive at rational pollution abatement and control. Already the gap between what is known and what is practically applied is much too great. What is needed is a wider application of stream analysis to rational design. Too often pollution abatement programs are designed and put into effect without ever having been analyzed as to what improvement they can be expected to produce or what degree of treatment is actually required for the particular stream. Engineering analysis is the fundamental basis for sound and economical design whether for a bridge or a sewage and waste treatment works. Adequate time and energy are generally devoted to the design of details of a treatment works but woefully little time is devoted to rational relation of the treatment works to the requirements of the stream and its natural purification capacities. This cannot be said of Mr. Kittrell and his fine TVA organization.

It is my experience that the conventional integrated oxygen sag equation is of little value in practical application except in the simplest of situations. This does not imply, however, that the B.O.D. criterion cannot be employed. The B.O.D. determination is only one element in the complex phenomenon of self-purification. It can be determined within quite as satisfactory limits as it is possible to measure the many other factors involved. The difficulty with the sag equation is that everything is lumped into the deoxygenation and reaeration coefficients in one integrated expression. This is gross over-simplification wherein all identification and differentiation of the real factors at play are lost. Hence, there is no adequate means of evaluating these coefficients to permit their rational modification for application to different stream conditions on a given river, and, certainly, it is pure folly to expect that the values determined on one river can be transferred to another.

The solution of this dilemma lies in breaking down the phenomenon of self-purification into its constituent parts and then dealing with each separately. This means abandoning the integrated equation and computing deoxygenation independently of reaeration. In turn, each of these major divisions is further subdivided to permit the direct application of the specific physical factors involved. Such a procedure requires considerable time and effort, but in my experience it is the only means of obtaining reliable evaluations of stream conditions.

The second point I wish to make is that river survey data (D.O.'s and B.O.D.'s) cannot be used in the computations and at the same time be employed as a check on the technique. Here again the integrated oxygen sag procedure falls short. If, however, deoxygenation and reaeration are computed separately in their subdivisions based upon the physical characteristics for each stretch of the river, it is possible to reserve the river B.O.D. and D.O. observations for an absolutely independent check on theoretical computations. For this it is necessary to determine the pollution load and its rate of satisfaction at its onshore source. Where river data are used the apparent difference in B.O.D. of two sampling stations in the river does not necessarily give the true rate of satisfaction of the organic matter. Sludge deposits, scour, biological adsorption, shortcircuiting, varying runoff, and all the errors and difficulties in obtaining representative samples are also reflected. These are important factors involved in self-purification, but they should be evaluated separately and not lumped into the rate of satisfaction of demand. It is not surprising, therefore, to find reported a wide range in rates determined from river sampling.

The analysis of the onshore wastes, however, entails more than just the 5-day B.O.D. It requires thorough investigation of the nature of the biochemical oxidation behavior over extended periods at different concentrations and in various dilution waters. It also entails the fractionalization of the B.O.D., particularly the suspended solids portion which may be involved in sludge deposits. From such analyses it is possible to determine with reasonable accuracy the total pollution debt and the true rate of its amortization. When this procedure is employed it will be found that the logarithmic rate of satisfaction of organic matter does not vary as much as some would have us believe.

In addition to the onshore pollution load and its characteristics, a careful survey of hydrologic and physical characteristics of the stream is required. With these basic data, deoxygenation and reaeration are computed separately in their fractional parts and then combined to give the resultant dissolved oxygen profile. This computed profile then can be compared with the independently observed river sampling data. Generally only minor adjustments in physical factors are necessary to obtain reasonable agreement between computed and observed results. When this is achieved it is then possible to compute with considerable reliability D.O. profiles which can be expected to prevail under various probabilities of drought and various reductions in pollution load. Such stream analysis is the only basis for rational design of pollution abatement and control.

I do not believe that it is necessary to employ empirical techniques. The procedure I have outlined is perfectly sound theoretically and can be practically applied. In our stream analysis work for National Council for Stream Improvement (of the Pulp, Paper, and Paperboard Industries) over the past five years we have successfully applied it to a number of streams in different parts of the country under a wide variety of conditions.

Procurement of West Coast Pulpwoods

JOHN M. McEWEN

Pulp mills on the West Coast have operated principally on hemlock logs with smaller amounts of white fir and Sitka spruce being used. The present trend is for fuller utilization of sound wood that was formerly logging or lumber mill waste. Sulphate mills are turning to Douglas fir, but its heartwood cannot be satisfactorily pulped by the sulphite process. West Coast logging in a sustained yield operation is by clear cutting of successive areas, not by selective cutting. Seed blocks are left to provide natural reforestation. Considerable pulpwood is made available by prelogging and relogging. Prelogging consists of cutting the small trees in an area with light equipment before they are damaged by the main operation. Another type of prelogging which may contribute more pulpwood in the future is the thinning of second growth stands to give the remaining trees more room to develop. Relogging is the salvaging of logging wastes with light equipment. Some mills have to provide wood room facilities for barking and chipping whole logs, cord wood, and slabs; as well as handle clear mill trimmings.

MANY have recently seen the logging and wood room operations on the West Coast. The species of wood and methods of handling large pulp logs are peculiar to this section of the country. The dominant species in the West Coast pulp producing area is Douglas fir. In fact, this section is sometimes called the Douglas fir region. Most of the pulp mills are located in the Puget Sound area with Seattle as the center, or in the Columbia River area with Portland as the major city. The Douglas fir region contains about a quarter of the commercially available timber in the United States. There were 425 billion board feet of Douglas fir in Western Washington and Oregon according to a 1945 forest survey (*1*). Lesser species reported in this survey included 125 billion board feet of western hemlock, and 58 billion board feet of true firs, such as white fir. Other species available in the quantity of over a billion board feet included Sitka spruce, lodgepole pine, mountain hemlock, and Englemann spruce. There are few hardwoods in this area. Some cottonwood and alder are pulped, but the bulk of the timber available is coniferous.

Timber operations in the Northwest are based on cutting Douglas fir for lumber. Over-all economy is gained by cutting all the species in a stand and separating them according to their ultimate use. Some of the earlier pulp mills were built in order to use the "weed" trees such as hemlock, Sitka spruce, and white fir. This gave the pulp mills a good supply of high-quality large logs which came as a byproduct from another operation. As the forests were cut and the demand for other wood products rose, especially during the war, other users began to bid against the pulp mills for these prime logs. This has induced the sulphite mills to use more cordwood and hemlock trimmings and slabs from saw mills. Sulphate mills began to use more Douglas fir as well as small wood of the traditional pulp species.

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TYPE OF LOGGING

Major logging operations on the West Coast are on a scale approaching that credited to Paul Bunyan. The big trees and rugged terrain require heavy equipment and skilled operators. Tree farms and sustained yield operations are not logged by selective cutting, but by clear cutting of successive areas of timber. Seed blocks of mature trees are left at strategic points so that the wind will do the job of reforesting the area. After an area is cut over, the debris is burned under carefully controlled conditions to remove a fire hazard to the new growth. This burning is at present the usual means of complying with state fire laws, but with better methods of cleaning up after clear cutting it may be possible to eliminate slash burning. It is estimated that reproduction is set back about 10 years because burning delays the seed germination. Hand planting is resorted to only when natural seeding fails. In other areas the selective cutting of mature trees every few years may be the best way to obtain sustained yield, but here the expense of moving the heavy equipment over the rugged terrain requires a maximum cut to be made at each stand. Also most of the trees of a typical Douglas fir forest are of about the same age. This means that they are all ready for harvest at the same time, and it is difficult to cut the close packed mature trees without damage to the few younger trees in the area.

The practices of prelogging and relogging are of special interest to pulp mills as this type of cutting produces timber particularly suitable for pulp. Relogging is the salvaging of small logs and usable sound chunks after the main logging operation has been completed. It is not economical to handle this material with the heavy equipment used for the main operation, but the total yield of the area can be greatly increased by relogging with light equipment. An average return of 10 cords per acre on relogging is not unusual. Of course this is an important conservation measure as well as a means to improve the return per acre.

Prelogging, or logging before the main cut, is of two types: precutting and thinning. It is often economical to log an area just before the main cut. In this way light equipment can be used to harvest small trees before they are damaged by falling mature trees in the clear cutting operation. Thinnings may be expected to furnish an increasing amount of pulpwood in the future. Nature has provided ideal timber growing conditions here on the West Coast and, if proper seed blocks are left, the new growth is quite thick

after a clear cutting operation. As the trees grow older they need more room to develop. After 30 to 40 years it is economical to thin the stand to provide pulpwood and to give the remaining trees more room to grow. It is anticipated that an "extra dividend" of about 20 cords per acre may be realized in this manner.

To summarize: the theoretical logging cycle consists of prelogging, clear cutting mature timber, relogging, slash burning, reforestation, thinning, prelogging, and cutting the second growth mature timber. The complete cycle for the Douglas fir region takes 80 to 100 years from the seed to merchantable timber. To go on sustained yield you simply obtain 100 times your yearly requirements, cut $^1/_{100}$ each year, and you are assured of a perpetual income—if bugs, forest fires, or tax collectors don't get you first.

This area is noted for the fact that it still has large reserves of uncut timber. This is both good and bad. It is good in that there is timber immediately available for harvest. The great wartime demand on the forest product industries could be met from these reserves. On the other hand, these mature forests are producing nothing. There is little new growth, and that is balanced by natural losses. The land cannot be made to produce wealth until the old growth is harvested. Then the new crop has a chance to grow. A wheat farmer would be thought very foolish if he did not harvest his crop every time it matured. Yet a tree farmer, who does not harvest his crop, is in a position similar to that of a wheat farmer who allows his wheat field to fall down and reseed itself every year. This does not mean that timber should be cut and wasted for the present generation with no thought for the future. However, our forests are not mineral deposits which cannot be replaced, but a resource which will renew itself time after time if given the opportunity. At present much effort is being expended to perfect plans so the highest rates of wood production will be maintained. This not only assures future generations of a supply of wood products, but is sound business management for a concern which expects to operate in the future. Pulp mills in particular gain from a sustained yield program since they are relatively high cost immovable installations compared to other wood using industries.

WOOD FOR SULPHITE PULPING

The basic raw material for sulphite pulp is hemlock logs cut in the main logging operations. This is the reason West Coast pulp mills have grown up on the basis of thousands of board feet rather than cords of wood. A thousand board feet is considered to be roughly equivalent to 2 standard 128-cubic foot cords. In recent years many mills have found it necessary to obtain wood from sources other than logs. One of the pulp mills in the Puget Sound area is a good example of a mill utilizing wood from many sources. They obtain rafts of logs, logs loaded on railroad cars, and logs trucked in by small operators. They utilize cord wood shipped in as long bundles on railroad cars from pre and relogging operations. They get so-called "farmer" cordwood in 8-foot lengths by truck. Byproduct wood from nearby sawmills comes in by rail in the form of slab wood and clear trimmings. Three separate barking and chipping systems are required to handle these different types of wood. Logs are handled by a large hydraulic barker and whole log chipper. Cordwood is processed by an Allis-Chalmers stream barker and a Carthage multiknife chipper. Slabs are barked on a hydraulic slab barker and chipped in a conventional chipper. Clear trimmings are put through the slab-chipping system.

Trying to account for logs, small wood, and mill trimmings when they all go into the same operation is quite a problem. In this instance the logs are scaled on a thousand board feet basis, while the small wood and mill trimmings are scaled as cords. Chips from each system are then passed over a weightometer to provide a check on how much each system contributes to the operation.

Hemlock, spruce, and white fir are the normal woods pulped, but great care must be taken to be sure that Douglas fir is not included in any of the wood lots used for the sulphite process. Douglas fir heartwood does not pulp by any of the normal methods and it is not very profitable to manufacture screenings in a pulp mill. John C. Pew of the Forest Products Laboratory has recently isolated a compound, 3, 3′, 4′, 5, 7-pentahydroxyflavone, which seems to be the material in Douglas fir heartwood which inhibits pulping (*2*). The sapwood pulps in a normal manner, but to date there have been no commercial installations of systems to separate Douglas fir heartwood and sapwood.

WOOD FOR SULPHATE PULPING

Any of the available woods can be pulped by the sulphate process. This provides a means of utilizing Douglas fir for pulp. Of course other industries compete with the pulp industry for Douglas fir logs, but there are vast amounts of prelogged and relogged Douglas fir available which are well suited for sulphate pulp. There is also a great deal of sound Douglas fir wood in the trimmings and slabs produced by the many sawmills in the area. The older sulphate mills used to operate mainly on the same species used by sulphite mills, but now the trend is toward the utilization of more Douglas fir. A 200-ton pulp mill requires roughly 800 tons of green wood per day. In most sections of the country, sawmills are so small, temporary, and scattered that slabs and trimmings could not be expected to furnish a very large amount of raw material for pulp. The dense stands of old growth on the West Coast provide so much timber within a reasonable hauling distance that it is economical to build large permanent sawmills. Such mills provide a constant source of an appreciable quantity of byproduct sound wood that is well suited for pulping. One of the Columbia River area pulp mills provides an example of an installation of this type. Slabs and trimmings from normal operation of the sawmills, and small logs from the integrated logging operation easily supply a 200 ton per day bleached sulphate mill. A rather unique feature of this installation is that the logs going to the main saw mill are barked by a hydraulic barker. These logs then give bark-free slabs which are much easier to process for pulp. In addition to the system set up to handle the wood supplied by the sawmills, facilities are provided to process pre- and relogged material.

This not only helps fully utilize the timber available but also provides an alternate source of supply in case the sawmills should drastically curtail production. Peeler cores from a plywood mill on the same lot also go into the small log system. Thus sound wood from many sources supplies the raw material for this mill.

Until recent years hemlock was the main wood pulp source for West Coast mills. Douglas fir bleached sulphate pulp has come into use with improvements in the multistage bleaching process. Due to its large size and rapid growth one would expect that Douglas fir would be a somewhat different type of fiber than either western hemlock or the eastern conifers. Its strength properties are characterized by its very high tearing resistance combined with lowered bursting strength.

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RECEIVED Sept. 26, 1949. Presented at the Fall Meeting of the Technical Association of the Pulp & Paper Industry held at the Multnomah Hotel, Portland, Ore., Sept. 12–15, 1949.

A Theory on the Development of Tensile Strength During the Beating of Pulp

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A theoretical equation is given for the development of tensile strength of a pulp during beating. The equation is based on the hypothesis that the tensile strength of pulp is a function of the hydrated and the unhydrated surface present. The development of hydrated surface is calculated from the hypothesis that only two effects are produced during beating: hydration and cutting. This equation fits experimental data investigated so far.

A SIMPLE mathematical explanation of the beating of pulp has been attempted by assuming:

1. The rate at which hydrated, fibrillated, or otherwise activated surface is formed, is proportional to the amount of unhydrated surface present.
2. The rate at which new surface (either hydrated or unhydrated) is exposed, is proportional to the amount of energy applied.
3. The tensile strength is a function of the probable contact between the hydrated surfaces, between the unhydrated surfaces, and between the hydrated and unhydrated surfaces.

From the above assumptions, the following equation is obtained:

$$T = T_0 + \{T_m - T_0\} \left\{ \frac{B\left[1 - \left(\frac{1}{1 + K\theta}\right)^{(B+K)/K}\right]}{B + K} \right\} \quad \text{(I)}$$

where

T = the tensile strength at time θ
T_m = the maximum tensile strength obtainable under the most ideal beating conditions
T_o = the tensile strength of the unbeaten pulp
K = a constant = the cutting rate for the particular beating equipment and pulp used
B = a constant = the hydrating rate for the particular beating equipment and pulp used
θ = the beating time

COMPARISON OF EXPERIMENTAL AND CALCULATED VALUES OF TENSILE STRENGTHS

This equation is not difficult to use and good agreement was found when it was applied to the actual beating of a bleached kraft pulp in the conventional laboratory beater. The tests were obtained from 40-pound (24 × 36—500) sheets made with a Noble and Wood sheet machine. Tests were conducted after conditioning at 73°F. and 50% relative humidity. The experimental and calculated figures are compared in Table I and Figs. 1a, 1b, 1c, 1d, 1e, and 1f.

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Graphical Calculation of Tensile Strength, Cutting Rate, and Hydrating Rate

Using case I, Table I, as an example:

1. Assume that a completely unbeaten pulp has a tensile strength of zero.
2. Plot the tensile strength obtained experimentally against the beating time and draw a smooth curve through the points (Fig. 1a). Extend the curve until it intersects the ordinate for tensile strength equals zero. It is found that this occurs when the beating time is —4 minutes.
3. Call the time when tensile strength equals zero, θ_0 and calculate the true beating times accordingly.

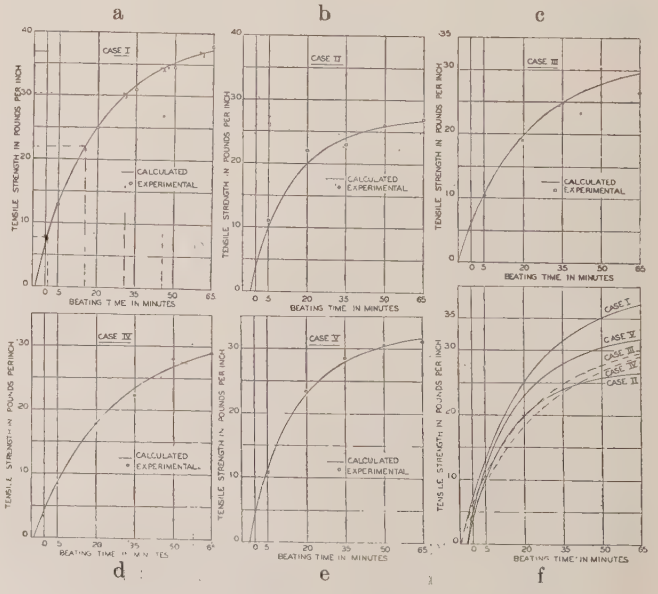

Fig. 1

Table I. Tensile Strength Development of the Same Pulp Under Different Beating Conditions

Actual Minutes in Beater	Case I			Case II			Case III			Case IV			Case V		
	True beating time	Tensile, Experimental	lb./in. Calculated	True beating time	Tensile, Experimental	lb./in. Calculated	True beating time	Tensile, Experimental	lb./in. Calculated	True beating time	Tensile, Experimental	lb./in. Calculated	True beating time	Tensile, Experimental	lb./in. Calculated
0	4	...	...	2	...	...	5	...	...	4	...	...	2	...	...
5	9	12.9	13.2	7	11.0	10.4	10	10.4	10.7	9	8.4	8.7	7	10.7	11.4
20	24	25.0	25.2	22	22.0	20.2	25	19.0	20.0	24	17.8	18.0	22	23.4	23.4
35	39	31.0	31.7	37	23.0	24.0	40	24.8	25.0	39	22.4	23.7	37	28.6	28.2
50	54	34.5	35.3	52	26.0	25.9	55	30.2	27.9	54	28.0	27.0	52	30.6	30.5
65	69	37.8	37.3	67	27.0	26.8	70	26.4	29.7	69	29.0	29.2	67	31.2	31.7
T_m			45			45			45			45			45
B (Beating rate)			0.037			0.044			0.030			0.0255			0.047
K (Cutting rate)			0.004			0.025			0.010			0.0075			0.016
$B/(B+K)$ (Beating Efficiency			0.90			0.64			0.75			0.77			0.75

Case I—Five dull bedplate knives in use, flybars dull, part of roll riding on bedplate babbitt, 5500 grams on bedplate.
Case II.—Seven sharp bedplate knives in use, flybars sharp, roll riding entirely on bedplate, 5500 grams on bedplate.
Case III—Seven medium sharp bedplate knives in use, flybars dull, roll riding entirely on bedplate knives, pressure on bedplate reduced some.
Case IV—Seven medium sharp bedplate knives in use, flybars dull, roll riding entirely on bedplate knives, pressure on bedplate reduced considerably.
Case V—Seven medium sharp bedplate knives in use, flybars dull, roll riding entirely on bedplate knives, 5500 grams on bedplate.

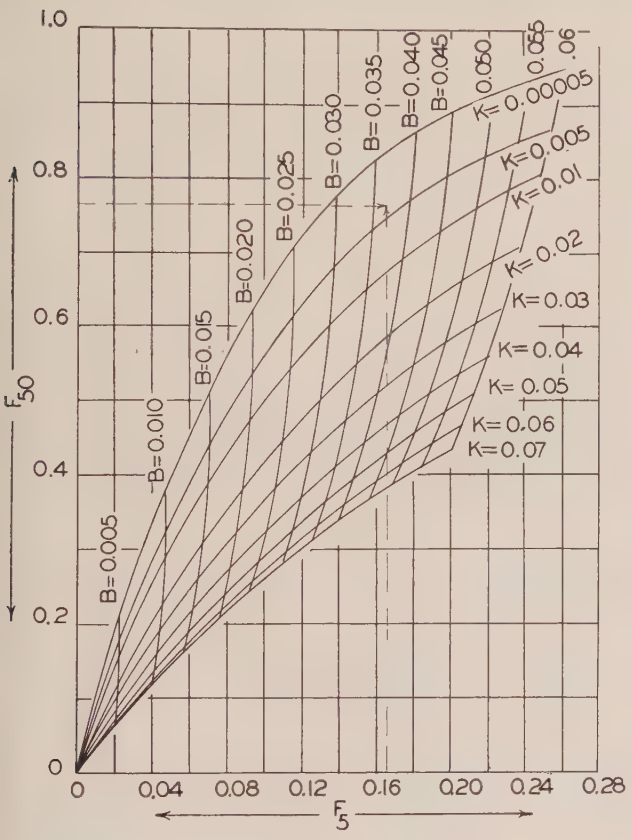

Fig. 2

True beating time = θ_0 = 0—4 = —4 actual minutes in the beater
True beating time = θ_5 = 5—4 = 1 actual minute in the beater
True beating time = θ_{20} = 20—4 = 16 actual minutes in the beater
True beating time = θ_{35} = 35—4 = 31 actual minutes in the beater
True beating time = θ_{50} = 50—4 = 46 actual minutes in the beater
True beating time = θ_{65} = 65—4 = 61 actual minutes in the beater

4. The value of the tensile strength (T_5) at true beating time θ_5 and the tensile strength (T_{50}) at true beating time θ_{50} is obtained from the curve. (See Fig. 1a.)

$T_5 = 7.46$ tensile at θ_5
$T_{50} = 34.4$ tensile at θ_{50}

The maximum tensile strength obtainable (T_m) must also be known. For this pulp $T_m = 45$ (estimated).

5. Now let

$$F_5 = T_5/T_m = \text{factor at } \theta_5$$

and let

$$F_{50} = T_{50}/T_m = \text{factor at } \theta_{50}$$

6. Substituting for T_5, T_{50}, and T_m

$$F_5 = 7.46/45 = 0.166$$

$$F_{50} = 34.4/45 = 0.764$$

7. Now using Fig. 2, determine B and K for the values $F_5 = 0.166$ when $F_{50} = 0.764$. It will be found that $B = 0.037$ hydrating rate and $K = 0.004$ cutting rate.

8. Using these values of B and K, obtain F_5, F_{20}, F_{35}, F_{50}, and F_{65} from Figs. 3, 4, 5, 6, and 7, respectively.

9. Using these values of F, calculate the tensile strengths as follows: write equation (I) as

$$T = T_0 + (T_m - T_0)F$$

Since T_0 is assumed to be equal to zero

$$T = T_m F$$

So

$T_5 = 45F_5 = 45 \times 0.166 = 7.46$ tensile after 1 minute in beater
$T_{20} = 45F_{20} = 45 \times 0.487 = 21.9$ tensile after 16 minutes in beater
$T_{35} = 45F_{35} = 45 \times 0.675 = 30.4$ tensile after 31 minutes in beater
$T_{50} = 45F_{50} = 45 \times 0.764 = 34.4$ tensile after 46 minutes in beater
$T_{65} = 45F_{65} = 45 \times 0.820 = 36.9$ tensile after 61 minutes in beater

Since the charts used in the graphical solution are based on equation (I), it is evident that when the values $B = 0.037$ and $K = 0.004$ are substituted in equation (I), the calculated values of tensile strength will agree with the experimental values. (See Fig. 1a.)

The values of tensile strength may also be calculated from equation (I) directly if desired, but the graphical solution is somewhat easier and as accurate as data will warrant.

General Application of Equation (I)

The charts were prepared for use with the laboratory beater where the pulp is fairly well beaten in

65 minutes, but these charts may be used for any beating or refining equipment.

Example: Unbeaten pulp is added to a mill scale beater and the roll is set. After 7 hours the tensile strength does not increase appreciably. Let 7 hours in the mill beater equal 65 minutes in the laboratory beater.

Mill beating time, hr.	*Equivalent laboratory beater time, min.*
0.00	0
0.54	5
2.16	20
3.78	35
5.39	50
7.00	65

Determine B and K by using the tensile strengths obtained at the equivalent laboratory beater times. Follow the procedure described under the heading "Graphical Calculation of Tensile Strength, Cutting Rate and Hydrating Rate." After the desired calculations have been made, B and K may be converted to their value for the mill beater as follows:

If $B = 0.04$ and $K = 0.01$ from Fig. 2 using the equivalent laboratory beater times, then the values for the mill beater will be:

$$B = \frac{0.04 \times 65}{7} = 0.37 = 37\% \text{ per hour for mill beater}$$

$$K = \frac{0.01 \times 65}{7} = 0.093 = 9.3\% \text{ per hour for mill beater}$$

This means that the mill beater hydrates at the rate of 37% of the unhydrated surface per hour, and that the beater increases the exposed surface area of the pulp at the rate of 9.3% of the original surface per hour.

Figure 2 was prepared as follows:

$$T = T_0 + \{T_m - T_0\} \left\{ \frac{B\left[1 - \left(\frac{1}{1 + K\theta}\right)^{(B + K)/K}\right]}{B + K} \right\} \text{(I)}$$

was written

$$T = T_o + (T_m - T_o)F$$

where

$$F = \left\{ \frac{B\left[1 - \left(\frac{1}{1 + K\theta}\right)^{(B + K)/K}\right]}{B + K} \right\}$$

Now by substituting different values of B, K, and θ, various values of F were calculated and these values of F plotted to obtain Fig. 2. (See Table II.)

Table II. Calculation of F for Various Values of θ, B, and K

θ	B	K	F	θ	B	K	K
5	0.01	0.01	0.046	5	0.01	0 02	0.045
50	0.01	0.01	0.27	50	0.01	0.02	0.23
5	0.02	0.01	0.091	5	0.02	0.02	0.087
50	0.02	0.01	0.47	50	0.02	0.02	0.39
5	0.03	0.01	0.13	5	0.03	0.02	0.125
50	0.03	0.01	0.59	50	0.03	0.02	0.50

DERIVATION OF THE EQUATION FOR TENSILE DEVELOPMENT DURING BEATING

For the purposes of this analysis, four arbitrary definitions have been devised.

1. *Surface Area*

When a fiber, fiber fragment, or fibril is so disposed that the maximum amount of its surface can be simultaneously brought into contact with a continuous surface which is unhydrated, this maximum amount of its surface is considered the surface area of the fiber, fiber fragment, or fibril. In this consideration, the unhydrated surface used for the mensuration may have any shape required to conform to the surface presented by the fiber, fiber fragment, or fibril as long as it exhibits no hydration properties when in that form.

2. *Hydrated Surface*

A hydrated surface is considered to be that surface of a fiber, fiber fragment, or fibril which has developed to the maximum amount, the property of bonding to another fiber surface. Any surface which has only a fraction of this maximum bonding property, is assumed to be composed of hydrated and unhydrated surfaces or of unhydrated surface. In this consideration, the bonding property referred to is that which can be developed by the application of mechanical energy.

3. *Unhydrated Surface*

An unhydrated surface is considered to be that surface of a fiber, fiber fragment, or fibril which has developed to the minimum amount the property of bonding to another fiber surface. Any surface which has more than this minimum bonding property, is assumed to be composed of hydrated and unhydrated surfaces or of hydrated surface.

4. *Cutting*

Cutting refers to any mechanical action which increases the surface area of a group of fibers under

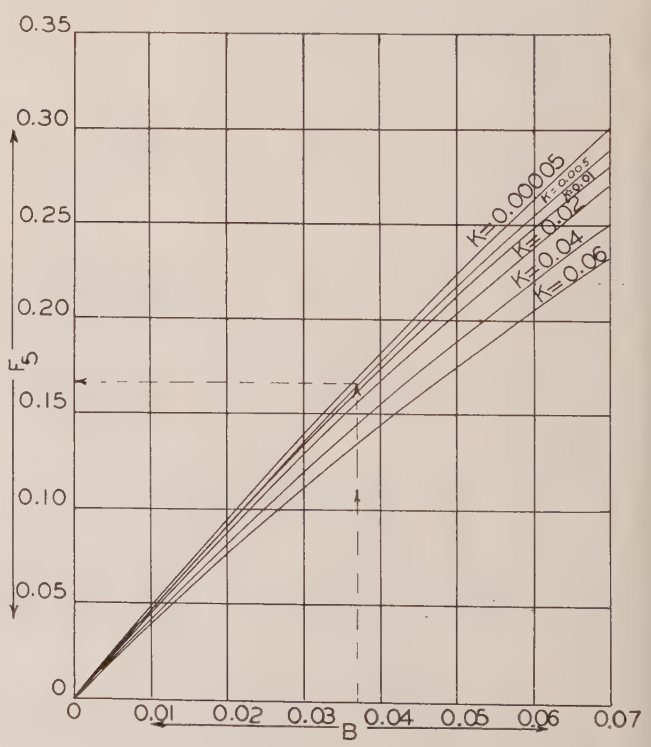

Fig. 3

consideration. The surface referred to is that defined in (1) above.

Assume that the rate at which pulp is hydrated is proportional to the fraction of unhydrated surface present.

$$\frac{dA}{d\theta} = \frac{B(S - A)}{S} \qquad (A)$$

where

A = hydrated area
θ = beating time
B = proportionality constant for hydrating rate
S = total surface area of pulp at time θ

Assume that the area of the surface exposed by cutting is proportional to the energy applied to the pulp. Assume that the energy applied is proportional to the beating time.

$$dR/d\theta = K \qquad (B)$$

Where

R = new surface exposed by cutting, either hydrated or, unhydrated

K = proportionality constant for cutting rate

Then

$$S = S_0 + R \qquad (1)$$

Where S_0 = total surface area of the unbeaten pulp. Now from equation (B)

$$R = K\theta \qquad (2)$$

From equations (1) and (2)

$$S = S_0 + K\theta \qquad (3)$$

From equation (A)

$$\frac{dA}{d\theta} = B - \frac{BA}{S} \qquad (4)$$

From equations (3) and (4)

$$\frac{dA}{d\theta} = B - \frac{BA}{S_0 + K\theta} \qquad (5)$$

$$\frac{dA}{d\theta} + \frac{BA}{S_0 + K\theta} = B \qquad (6)$$

Equation (6) is a linear differential equation.

$$\text{The integrating factor} = (S_0 + K\theta)^{B/K} \qquad (7)$$

$$A(S_0 + K\theta)^{B/K} = B \int (S_0 + K\theta)^{B/K}\, d\theta + \text{constant} \qquad (8)$$

$$A(S_0 + K\theta)^{B,'K} = \frac{B}{B + K}(S_0 + K\theta)^{\frac{(B + K)}{K}} + \text{constant} \qquad (9)$$

When $\theta = 0$; $A = 0$, therefore constant $= -B(S_0)/B + K^{(B + K)/K}$. Substituting the constant in equation (9) and solving for A.

$$A = \frac{B}{B + K}\left[(S_0 + K\theta) - S_0{}^{(B + K)/K}\left(\frac{1}{S + K\theta}\right)^{B/K}\right] \qquad (10)$$

$$A = B\left[\frac{(S_0 + K\theta) - S_0\left(\frac{S_0}{S_0 + K\theta}\right)^{B/K}}{B + K}\right] \qquad (11)$$

The most probable fraction of hydrated surface in contact with hydrated surface is

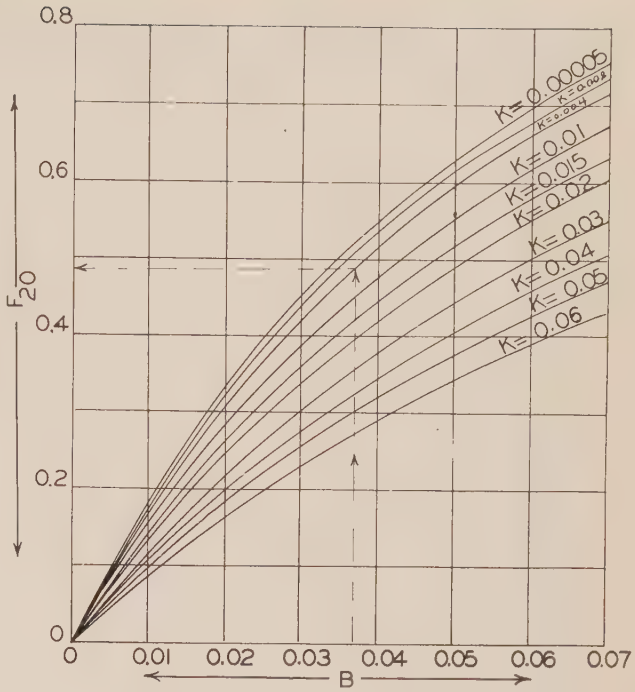

Fig. 4

$$\left(\frac{A}{S}\right)\left(\frac{A}{S}\right) = \frac{A^2}{S^2} \qquad (12)$$

The most probable fraction of unhydrated surface in contact with unhydrated surface is

$$\left(\frac{S - A}{S}\right)\left(\frac{S - A}{S}\right) = \frac{(S - A)^2}{S^2} \qquad (13)$$

The most probable fraction of *hydrated surface* in contact with unhydrated surface is

$$\left(\frac{A}{S}\right)\left(\frac{S - A}{S}\right) = \frac{A(S - A)}{S^2} \qquad (14)$$

The most probable fraction of *unhydrated surface* in contact with hydrated surface is

$$\left(\frac{S - A}{S}\right)\left(\frac{A}{S}\right) = \frac{A(S - A)}{S^2} \qquad (15)$$

The most probable fraction of hydrated and unhydrated surface in contact is

$$\frac{A(S - A)}{S^2} + \frac{A(S - A)}{S^2} = \frac{2A(S - A)}{S^2} \qquad (16)$$

Assume the bond between hydrated surfaces is equal to the maximum bond obtainable between fibers; equals T_m.

Assume the bond between unhydrated surfaces is equal to the bond between fibers in the unbeaten pulp; equals T_0.

Assume the bond between hydrated and unhydrated surfaces is equal to one of the following:

Bond between hydrated surfaces; equals T_m
Bond between unhydrated surfaces; equals T_0
Average of the above two bonds; equals $(T_m + T_0)/2$

This leads to three possible equations for tensile strength using equations (12), (13), or (16).

$$T = T_0\frac{(S - A)^2}{S^2} + T_m\frac{(A)^2}{S^2} + T_m\frac{2A(S - A)}{S^2} \qquad (C_1)$$

$$T = T_0\frac{(S - A)^2}{S^2} + T_m\frac{(A)^2}{S^2} + T_0\frac{2A(S - A)}{S^2} \qquad (C_2)$$

$$T = T_0\frac{(S - A)^2}{S^2} + T_m\frac{(A)^2}{S^2} + \frac{(T_m + T_0)}{2}\frac{2A(S - A)}{S^2} \qquad (C_3)$$

Table III. Effect of Fiber Length and Per Cent of Pulp Beaten on Tensile Strength, Lb./In.

Per cent of beaten pulp by weight	Observed tensile strength	Calculated tensile from equation C_3	C_2	C_1	Pulp used	Mesh of fibers
0	0.7	...	...	...	Alpha	+20
20	3.4	3.6	1.3	6.0	Alpha	+20
47	6.6	7.6	3.9	11.2	Alpha	+20
70	11.3	10.9	7.9	13.3	Alpha	+20
100	15.3	...	...	...	Alpha	+20
0	1.5	...	...	...	Alpha	−20 +150
25	4.4	4.7	2.3	6.9	Alpha	−20 +150
50	7.1	7.9	4.7	11.1	Alpha	−20 +150
75	11.5	11.1	8.7	13.5	Alpha	−20 +150
100	14.3	...	...	...	Alpha	−20 +150
0	14	...	...	...	Bl. sulphate	−150
50	22	21.5	17.8	25.2	Bl. sulphate	−150
100	29	...	...	...	Bl. sulphate	−150
0	9	...	...	...	Bl. sulphate	−65 +150
50	21	20.0	14.5	25.5	Bl. sulphate	−65 +150
100	31	...	...	...	Bl. sulphate	−65 +150
0	10	...	...	...	Bl. sulphate	−35 +65
50	21	20.0	15.0	25.0	Bl. sulphate	−35 +65
100	30	...	...	...	Bl. sulphate	−35 +65
0	10	...	...	...	Bl. sulphate	−20 +35
50	18	18.5	14.2	22.8	Bl. sulphate	−20 +35
100	27	...	...	...	Bl. sulphate	−20 +35
0	8.8	...	...	...	Bl. sulphate	+20
50	18	19.4	14.1	24.7	Bl. sulphate	+20
100	30	...	...	...	Bl. sulphate	+20

These equations may be checked as follows:

An unbeaten pulp is classified to a definite fiber length. Also some of the same pulp is thoroughly beaten and classified to the same fiber length. Assume that equal weights of the beaten or unbeaten pulp have approximately the same effective external surface area. When this is done, equations (C_1), (C_2), (C_3), may be simplified by letting A equal the fraction by weight of beaten pulp in a mixture of beaten and unbeaten pulp. Under these conditions S becomes equal to 1.

Then Equation (C_1) becomes

$$T = T_0 + (T_m - T_0)(2A - A^2)$$

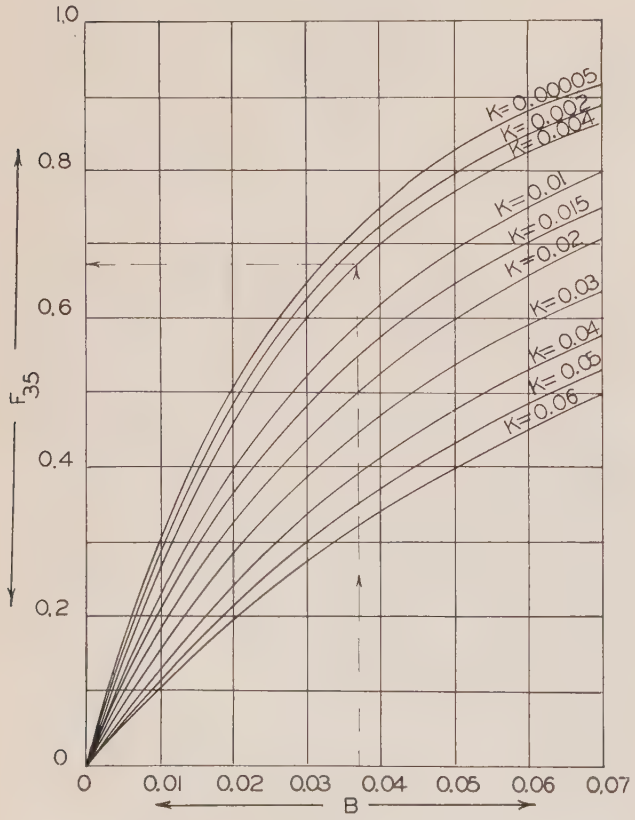

Fig. 5

Equation (C_2) becomes

$$T = T_0 + (T_m - T_0)(A)^2$$

Equation (C_3) becomes

$$T = T_0 + (T_m - T_0)(A)$$

Now if varying percentages by weight of the beaten and unbeaten pulp are mixed and sheets formed, the resulting tensile strengths may be measured and also calculated by letting T_0 equal the tensile of the unbeaten pulp and T_m equal the tensile of the beaten pulp. When this done, it will be seen that equation (C_3) best fits experimental results. (See Table III). This method shows that equation (C_2) does not fit the experimental results, that equation (C_1) probably does not fit experimental results, and that equation (C_3) probably does fit experimental results.

Now if the value of A derived in equation (11) is substituted in equation (C_3)

$$T = T_0 + \{T_m - T_0\} \left\{ B \left[\frac{(S_0 + K\theta) - S_0 \left(\frac{S_0}{S_0 + K\theta} \right)^{B/K}}{S(B + K)} \right] \right\} \tag{17}$$

From equation (3)

$$S = S_0 + K\theta$$

Let

$$S_0 = 1$$

Then

$$T = T_0 + \{T_m - T_0\} \left\{ \frac{B \left[1 - \left(\frac{1}{1 + K\theta} \right)^{(B+K)/K} \right]}{B + K} \right\} \quad \text{(I)}$$

Some Comments on Equation (I)

1. For moderate variations in fiber length, the equation appears to give accurate results. As the equation is derived, no effect of fiber length is included. Table III shows that this is probably justified for moderate variations in fiber length. This means that cutting of

a gouging nature has an effect on tensile, but cutting which shortens the fibers has little effect until the fibers become quite short. A theoretical equation which has not been checked experimentally, includes a correction for fibrils and short fibers or fragments. It may be derived as follows:

Assume

$$\frac{d\phi}{d\theta} = f(k,K,A/S)$$

where

ϕ = the sum of the plane projected areas of the fibril or fragment
k = a constant
K, A, and S have the same value as in equation (I)
θ = beating time

The probability of the fibrils or fragments falling on unhydrated surface is

$$d\Sigma = \frac{S - A - \Sigma}{S} d\phi$$

where Σ is the area of unhydrated surface covered by fibrils or fragments.

Assume that the bond between unhydrated surface covered by fibrils or fragments and any other surface,

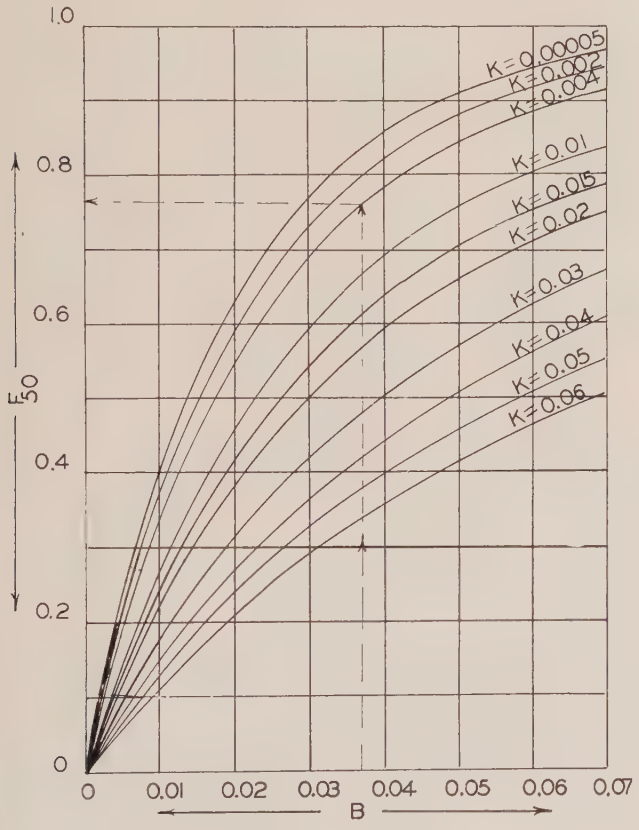

Fig. 6

equals the bond between hydrated and unhydrated surfaces. (See equation (C_3).)

Then

$$T = T_0 \frac{(S - A - \Sigma)^2}{S^2} + T_m \frac{A^2}{S^2} + \left[\frac{T_m + T_0}{2}\right] \left[\frac{\Sigma^2 + 2\Sigma(S - A - \Sigma) + 2A(S - A - \Sigma) + 2A\Sigma}{S^2}\right]$$

2. If the effect of cutting of fibers is not included in the derivation of the equation, a simple exponential equation is obtained. However, this equation does not explain the fact that the tensile versus beating time curves on the same pulp, but with different beating conditions, cross one another. (See Fig. 1f.)

3. It can be seen by inspection that equation (I) states the following:

(a) When $\theta = 0$; T = tensile strength of unbeaten pulp.

(b) When $\theta = \infty$; $T = T_0 + (T_m - T_0)\, B/(B + K)$ which means that the maximum tensile will be realized

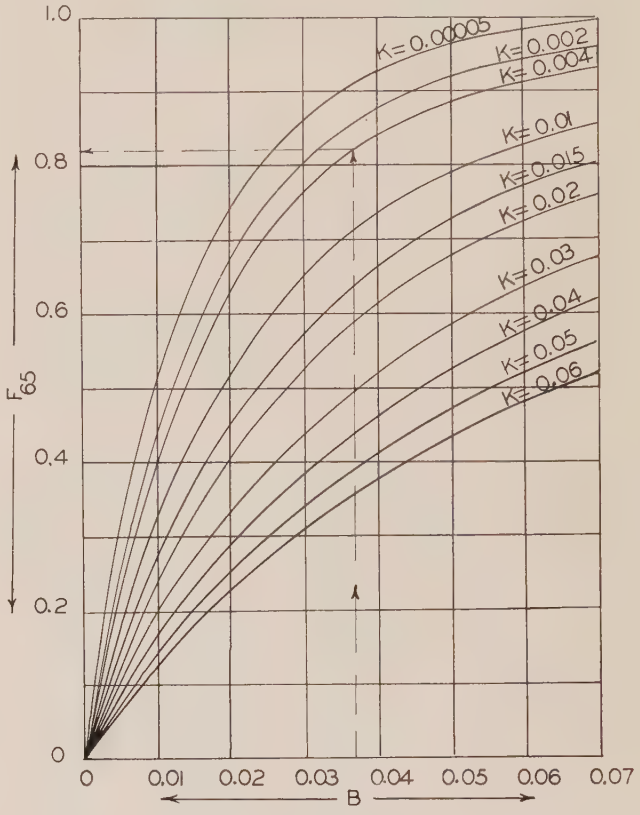

Fig. 7

only if the cutting rate is small compared to the hydrating rate.

(c) No matter how fast the cutting rate or how slow the hydrating rate, the tensile strength will always increase with beating time and asymptotically approach the value $T = T_0 + (T_m - T_0)\, B/(B + K)$. The cases where B or K equals zero are excluded from this statement. There will not be a maximum tensile followed by a decrease in tensile strength. Cases where beating is continued to the point of brittleness may result in lower tensile test results due to unequal distribution of stresses.

(d) The equation behaves logically for values of K which approach zero, but does not give reasonable results when K equals zero. In effect it states that there will be no increase in tensile unless cutting action is present.

4. From Fig. 3, it is apparent that the development of tensile strength during the first few minutes of beating is more affected by the hydrating rate than by the cutting rate. However, the final tensile is greatly

affected by the cutting rate, as is shown in Fig. 7.

5. The determination of the constants B and K is not difficult, but the determination of T_0 and T_m is difficult. It is believed that some type of parchmentizing, the use of the zero span tensile, tensile of individual fibers, or the method of Pepper and Barwell might give a fairly close estimate of T_m. The method of Pepper and Barwell is described by C. J. Straka in the "Proceedings of 1948 Plastics Conference" sponsored by Plastics Committee of the Technical Association of the Pulp and Paper Industry, August 16–17, 1948. T_0 is probably close to zero for most wood pulps.

6. A more reliable method of estimating the time when tensile strength is zero, is the following.

From equation (I)

$$\log\left[1 - \frac{(B + K)T}{BT_m}\right] = -\left(\frac{B + K}{K}\right)\log(1 + K\theta)$$

If experimental values of T, B, and K are substituted in this equation along with the estimated true values of beating time, then a plot of the above equation should be a straight line passing through the origin with a slop of $-\left(\frac{B + K}{K}\right)$. This appears to be true for the experimental data examined. (See Table IV and Fig. 8.)

7. The beating or hydrating efficiency of the beater

Table IV. Data for Logarithmic Plot of Tensile Versus Beating Time

Minutes in the beater	θ	$Log\left[1 - \frac{(B + K)T}{BT_m}\right]$	$Log\ (1 + K\theta)$	*Case taken from Table I*
5	9	−0.166	0.0153	I
20	24	−0.414	0.0399	I
35	39	−0.625	0.0630	I
50	54	−0.821	0.0849	I
65	69	−1.155	0.1059	I
5	7	−0.173	0.0701	II
20	22	−0.631	0.190	II
35	37	−0.699	0.284	II
50	52	−1.022	0.362	II
65	67	−1.222	0.427	II
5	10	−0.160	0.0414	III
20	25	−0.358	0.0969	III
35	40	−0.575	0.146	III
50	55	−0.975	0.190	III
65	70	−0.680	0.230	III
5	9	−0.120	0.0286	IV
20	24	−0.312	0.0719	IV
35	39	−0.450	0.113	IV
50	54	−0.712	0.148	IV
65	69	−0.782	0.181	IV
5	7	−0.167	0.0461	V
20	22	−0.520	0.1309	V
35	37	−0.836	0.202	V
50	52	−1.060	0.263	V
65	67	−1.161	0.317	V

may be expressed as $B/(B + K)$. The cutting efficiency (not necessarily fiber shortening) may be expressed as $K/(B + K)$. When this is done, the sum of the beating efficiency and the cutting efficiency equals unity.

8. In Table I, cases III, IV, and V, it appears that the beating efficiency is not appreciably affected by moderate variations in bedplate pressure, if the condition of the tackle remains constant. However, the beating rate is appreciably affected by moderate variations in the bedplate pressure.

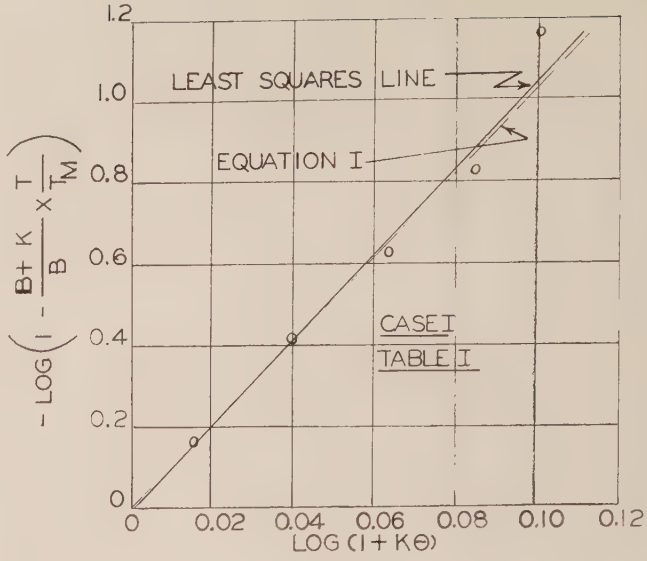

Fig. 8

9. In this analysis it has been assumed that all surfaces are in contact with some other fiber surface. This assumption, of course, is not true, but for ordinary beating conditions does not seem to lead to inconsistencies in equation (I). However, the effect of surfaces not in contact may show up when very short fibers are compared with long fibers in that short fibers seem to give higher tensile strengths. (See Table III.)

A correction for this effect might be derived by assuming:

(a) The amount of free surface (surface not in contact with any other fiber surface) is a function of fiber lengths.

(b) Fiber lengths are a function of beating time, cutting rate, and original fiber lengths.

(c) Tensile strength is proportional to the total surface area minus the free surface area.

10. When equation (I) is corrected for comments (1) and (9), it will be of the following form:

$$T = \left[\frac{S - S_f}{S}\right]\left[T_0 + (T_m - T_0)\left(\frac{2AS + 2\Sigma S - 2A\Sigma - \Sigma^2}{2S^2}\right)\right]$$

where S_f = the amount of surface not in contact with any other fiber surface.

CONCLUSIONS

The equation has been derived principally for theoretical interest. Neither careful nor extensive experimental work has been done. If the equation is valid, a possible use is suggested in the study of beating equipment. By its use, the beating rate and beating efficiency can be quickly and easily evaluated. In doing this, unbeaten pulp should be used at the start and recirculated until the tensile strength ceases to increase appreciably. The setting of the roll, disk, or plug should not be changed during the beating period. A means of calculating the beating and cutting rates for this type of test is given under the heading "General Applications of Equation (I)."

It is hoped that experimental work will be done to prove or disprove the correctness of assumptions made in this analysis.

Received May 31, 1949.

Certain Factors That Influence Delignification in Acid Sulphite Pulping

GEORGE A. RICHTER

This paper deals with some of the factors that play important roles in determining the ease or the difficulty of delignification with bisulphites and with sulphurous acid itself. It has long been recognized that in acid sulphite pulping ease of delignification can be greatly influenced by conditions that exist before maximum temperatures are reached. Not only can early digestion history interfere seriously with removal of lignin during pulping, but in many cases the lignin remaining in the pulp product becomes more difficult to eliminate in subsequent bleach stages. The influence of initial high temperatures in the absence of sulphites or high free sulphurous acid solutions is particularly detrimental to subsequent pulping unless such high temperature treatment has been preceded by a sulphonation step. Under some conditions of pretreatment, the lignin is rendered almost wholly inert to later removal by sulphurous acid or by sulphite. On the other hand, when sulphonation is particularly favored in a prestep, a second stage digestion that allows additional sulphonation or sulphurous acid hydrolysis or both will result in almost complete delignification. The results of this investigation also show that an effective presulphonation can be followed with a high-temperature aqueous treatment of a sort that will in itself ordinarily cause the lignin to become unreactive, without appreciable interference in a third stage pulping with sulphite solutions. It is believed that the experimental findings explain, to a large extent some of the experiences that are encountered in orthodox pulping procedures.

THE PAST decade has witnessed much new experimental effort aimed to extend the understanding of delignification of wood by old and new pulping procedures. Much of this study has centered on the analysis of spent liquors that result from such digestions. Other experimenters have approached the problem through a study of chemical changes that occur in the wood when subjected to the various types of treatment. A third approach comprises an experimental study of cause and effect relationships that take place in pulping when conditions are deliberately altered to favor or to interfere with reactivity and with removal of lignin.

This paper is concerned almost wholly with the third type of approach and is confined to experimental results obtained with western hemlock wood and sulphurous acid, or bisulphite pulping. Most of the work was done with carefully sorted laboratory chips cut $^3/_4$ inch along the grain and with $^1/_8$ inch thickness. Uniform and reproducible chip design is essential if several series of digestions are to be compared, since the rate and the degree of penetration of the various reagents into the wood structure are often determining factors. In all cases the treatments were carried out in rocking digesters in which temperature, pressure, and circulation can be adequately controlled and maintained. Wood chip charges comprised 1700 grams figured on a dry basis and in all cases the wood had an initial moisture content of between 40 and 50%. Since the main purpose was to study factors that interfere with normal delignification, many of the experiments cited did not include a screening of the final product. In those cases yield and lignin were determined on thoroughly blended samples of the entire product mass.

There is substantial agreement on the part of many investigators of sulphite pulping processes that removal of lignin from wood and other natural cellulosic materials depends on sulphonation and a subsequent hydrolysis of the sulphonated lignin. In acid sulphite cooking the hydrolysis is achieved by the free sulphurous acid present. When combined SO_2 is present the sulphonic acid groups, which are split off in the hydrolysis, are progressively removed by reaction with the weaker acid salt. This prevents undesirable attack of strong sulphonic acid groups on lignin and cellulose itself during the high-temperature stage of the cook. When delignification is accomplished by substantially neutral sulphites, hydrolysis is explained by reaction of sulphonates with water at elevated temperatures.

Any condition of digestion that falls short of or interferes with proper and sufficient sulphonation of the lignin initially present can have important influence on subsequent solubilization of the lignin groups. Likewise, with some wood species, certain secondary constituents of original wood substance can cause serious interference of lignin removal by reason of initial reaction that takes place between the secondary groups and lignin. In such instances the early reaction is frequently referred to as resinification, or polymerization, or condensation.

Whether such first-stage reaction of lignin with secondary substances results in an intermediate that refuses to sulphonate or whether the sulphonation does occur but the resulting sulphonated lignin complex then resists the solubilizing hydrolysis reaction is not clear. Some of the experimental evidence submitted below points toward the latter possibility since substantial addition of the sulphur group can be demonstrated in wood products which have undergone deleterious first-stage treatments and then have been subjected to unsuccessful pulping attempts with sulphurous acid solutions.

There is a strong probability that even in woods that are relatively free of the secondary substances

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Table I. Influence of Pretreatments on Delignification

Wood = western hemlock—40% H_2O content.
First-stage cook = digestion in water, maximum temperature x °C., applied pressure 100 pounds, 2 + 4 hours.
Second-stage cook = in all cases digestion of pretreated wood in 15% SO_2 solution, maximum pressure 150 pounds, maximum temperature 110 °C., 1 + 7.5 hours.[a]
Washing practiced between first and second stages.

	Stage 1 (water pretreat)							
Maximum temperature, °C.	60	75	110	120	130	150	170	None
Step yield, %	97	97	97	96	96	87	76.1	
pH at end of cook	6.8	6.6	5.3	4.3	3.8	3.7	3.4	
	Stage 2							
Over-all yield, %	50.6	51	49	51.4	60	66.4	69.9	49.9
Lignin, %	7.9	8.1	7.4	11.5	17.1	32.9	38.1	9.9
Lignin removed, %	86.7	86.3	87.9	80.5	65.8	27.5	11	83.9
Nonlignin removed, %	33.5	33	35.5	34.5	29	36.5	38	36

[a] Maximum temperature was reached in 1 hour and held there 7.5 hours.

mentioned above and which under ordinary conditions pulp very readily, lignin itself can polymerize, and in such cases subsequent pulping with acid sulphite liquors is wholly impossible. Experimental data cited below lend some support to this conception.

Tables I through VIII comprise two-stage digestions in which the second was made with 15% SO_2 solution that contained no combined sulphite. In many cases the first stage treatments were designed deliberately to exaggerate their influence on ultimate delignification. Comparison cooks were made in which the first-stage treatment was omitted.

In Table I water was used in the first stage. Maximum temperatures range from 60 to 170°C. and maximum temperatures were held for 4 hours. Nitrogen was applied where needed to maintain a pressure of 100 pounds. pH's of spent liquors were recorded and first-stage yields determined. All second stages were made with 15% SO_2 solution using a maximum temperature of 110°C. for 7.5 hours and a maximum pressure of 150 pounds. Final thoroughly blended but unscreened products were measured for yield and lignin.

As expected, the pH of spent liquors from the water cooks decreases progressively with increased temperatures. Intermediate yield is in the same order. Marked reductions are noted as temperatures approach 170°C.

On the other hand, over-all yields as measured on the final products show increase with increasing first-stage temperatures, and lignin in finished products rises sharply when first-stage temperatures exceed 120°C. Only 11% of the total lignin was removed when water temperatures were established at 170°C. It is of interest to note that loss of nonlignin material throughout the series is substantially the same.

Table II lists cooks in which the first-stage treatments were made with a 2% sodium sulphite solution. Otherwise they were like cooks in Table I. The important protecting influence of the weak sodium sulphite is self-evident. Even in pretreats run at 170°C., subsequent delignification is easily accomplished and in much greater degree than in the comparison cook itself. This beneficial influence of sodium sulphite cannot be explained by the presence of combined SO_2 in the second stage pulping since all intermediate products were well washed several times by overnight water soaks. In fact, in an experiment not shown, even when the intermediate chip product was acid washed and extracted to an ash level of 0.05%, subsequent delignification with the sulphurous acid solution was substantially complete. The combined sulphur content in the thoroughly washed product that had undergone the sodium sulphite digestion at 170°C. was 0.85%. The corresponding lignin of that same product was found to be 23.3%. In other words, sulphur based on lignin content equaled 3.6%.

A series of double cooks in which the first-stage treatments are made with 1% sodium hydroxide solutions are shown in Table III. The deleterious influence of the pretreat reagent becomes evident at temperatures as low as 75°C. Marked interference with delignification is found with first-stage temperatures of 130°C.

As shown in Table IV, exposure of wood to weak

Table II. Influence of Pretreatments on Delignification

Wood = western hemlock—40% H_2O content.
First-stage cook = digestion with 2% Na_2SO_3 solution, maximum temperature x °C., applied pressure 100 pounds, 2 + 4 hours.
Second-stage cook = in all cases digestion of pretreated wood in 15% SO_2 solution, maximum pressure 150 pounds, maximum temperature 110 °C., 1 + 7.5 hours.
Washing practiced between first and second stages.

	Stage 1 (2% Na_2SO_3 solution)				
Maximum temperature, °C.	130	150	170	170[a]	None
Step yield, %	96.1	87.6	80.5	78	
	Stage 2				
Over-all yield, %	50.6	49.0	50.2	47.9	49.9
Lignin, %	0.86	0.89	1.26	0.97	9.9
Lignin removed, %	98.5	98.5	97.9	98.5	83.9
Nonlignin removed, %	28.5	30.5	29	31.5	36

[a] 5% Na_2SO_3 used in first stage.

Table III. Influence of Pretreatments on Delignification

Wood = western hemlock—40% H_2O content.
First-stage cook = digestion in 1% NaOH solution, maximum temperature x °C., applied pressure 100 pounds, 2 + 4 hours.
Second-stage cook = in all cases digestion of pretreated wood in 15% SO_2 solution, maximum pressure 150 pounds, maximum temperature 110 °C., 1 + 7.5 hours.
Washing practiced between first and second stages.

	Stage 1 (1% NaOH solution)					
Maximum temperature, °C.	50	60	75	100	130	None
Step yield, %	95.1	95.1	93	92.9	90.9	
	Stage 2					
Over-all yield, %	54.5	57.6	66.6	70.6	74	49.9
Lignin, %	9.9	11.7	23.2	25.8	31	9.9
Lignin removed, %	82	77.5	48.5	39.5	23.5	83.9
Nonlignin removed, %	30	27.5	27	24	27	36

Table IV. Influence of Pretreatments on Delignification

Wood = western hemlock—40% H_2O content.
First-stage cook = digestion in SO_2 solution.
Second-stage cook = in all cases digestion of pretreated wood in 15% SO_2 solution, maximum pressure 150 pounds, maximum temperature 110°C., 1 + 7.5 hours.
Washing practiced between first and second stages.

	Stage 1 (SO_2 solution)						
Chemical	1% SO_2	1% SO_2	1% SO_2	1% SO_2	1% SO_2	5% SO_2	
Pressure, lb.	100	100	100	100	100	100	
Temperature, °C.	85	100	115	130	150	130	None
Time, hr.	2 + 4	2 + 4	2 + 4	2 + 4	2 + 4	2 + 4	
1st-stage yield, %	94.9	81.3	74.5	67	63.8	...	
	Stage 2						
Over-all yield, %	51.2	57.7	62.1	67.2	61.2	60.5	49.9
Lignin, %	10.2	26.4	31.6	39.7	46.3	35.7	9.9
Lignin removed, %	82.5	49	35	11.5	6	28	83.9
Nonlignin removed, %	34.5	39.5	39.5	42	53	44	36

SO_2 solutions is particularly bad at a temperature of about 100°C. With a pretreat temperature of 150°C., a following cook in the 15% SO_2 solution shows no further loss in yield ,and over-all lignin removal is only 6%. Lesser effect is shown in the last double cook cited in Table IV. This is attributed to the higher free SO_2 in the first stage. Additional evidence of the influence of stronger SO_2 solutions in the first stage is given in Table V. It appears that a 1% SO_2 solution promotes a conversion of lignin to an inert form, whereas the higher concentrations allow sulphonation to proceed more normally. In other words, the weak SO_2 solution functions primarily as an acid rather than as a sulphonating agent. These results help explain the fact that the pulpmaker can go to maximum temperature in short time more successfully with high than with low free SO_2 solutions. In mill cooking, the thickness of chips is a second important factor, since with increased thickness a complete penetration of reagent into wood becomes slower. If the digester temperature is raised too rapidly, low concentrations of free SO_2 reach the center of the chips quickly, the protective influence of the combined SO_2 in the center of the larger chips is lost, and the lower concentration of free SO_2 within the chips than obtained in the surrounding solution during the early

Table V. Influence of Increasing Percentages of SO_2 in Pretreats

	Stage 1[a]				
Free SO_2, %	1	5	15	25	
Temperature, °C.	100	100	100	100	
Time, hr.	2 + 4	2 + 4	2 + 4	2 + 4	None
Pressure, lb.	100	100	100	100	
	Stage 2				
Free SO_2, %	15	15	15	15	15
Temperature, °C.	110	110	110	110	110
Time, hr.	1 + 7.5	1 + 7.5	1 + 7.5	1 + 7.5	1 + 7.5
Pressure, lb.	150	150	150	150	150
Yield, %	62.1	52	50	47.5	49.9
Lignin, %	26.4	11.2	5.2	3.5	9.93
Lignin removed, %	45.5	81.6	91.7	94.5	83.9
Nonlignin removed, %	35	34	32.5	34.5	36

[a] Intermediate products were thoroughly washed.

Table VII. Influence of Pretreatments on Delignification

Wood = western hemlock—40% H_2O content.
First-stage cook = as indicated in table below.
Second-stage cook = in all cases digestion of pretreated wood in 15% SO_2 solution, maximum pressure 150 pounds, maximum temperature 110°C., 1 + 7.5 hours.
Washing practiced between first and second stages.

	Stage 1				
Chemical	2% Na_2S	2% Na_2S	2% Na_2S	2% Na_2S + 0.5% S	
Pressure, lb.	100	100	100	100	
Temperature, °C.	130	150	170	130	None
Time, hr.	2 + 4	2 + 4	2 + 4	2 + 4	
1st-stage yield, %	79	73	...	...	
	Stage 2				
Over-all yield, %	63.5	66.5	69.6	68.4	49.9
Lignin, %	30.2	31.9	33.4	29.1	9.9
Lignin removed, %	36.5	30	22.5	34	83.9
Nonlignin removed, %	36.5	35	34	30	36

Table VI. Influence of Pretreatments on Delignification

Wood = western hemlock—40% H_2O content.
First-stage cook = as indicated in table below.
Second-stage cook = in all cases digestion of pretreated wood in 15% SO_2 solution, maximum pressure 150 pounds, maximum temperature 110°C., 1 + 7.5 hours.
Washing practiced between first and second stages.

	Stage 1					
Chemical	1% NaOH + 1% Na_2SO_3	Same	1% free SO_2 + 1% comb. SO_2	Same	Same	
Pressure, lb.	100	100	100	100	100	
Temperature, °C.	130	150	130	150	170	None
Time, hr.	2 + 4	2 + 4	2 + 4	2 + 4	2 + 4	
1st-stage yield, %	83.6	83	86.6	68.4	...	
	Stage 2					
Over-all yield, %	61.4	63.6	47.7	47.3	38.8	49.9
Lignin, %	20.1	24	1.3	0.73	2.6	9.9
Lignin removed, %	59	49	97.9	98.8	96.7	83.9
Nonlignin removed, %	30	31	32.5	33	46	36

Table VIII. Influence of Pretreatments on Delignification

Wood = western hemlock—40% H_2O content.
First-stage cook = as indicated in table below.
Second-stage cook = in all cases digestion of pretreated wood in 15% SO_2 solution, maximum pressure 150 pounds, maximum temperature 110°C., 1 + 7.5 hours.
Washing practiced between first and second stages.

			Stage 1				
Chemical	H_2O	1% HCOOH	1%AcOH	2% $Na_2S_2O_3$	2% Na_3PO_4	2% Na_2SO_4	2% $Na_2B_4O_7$
Pressure, lb.	100	100	100	100	100	100	100
Temperature, °C.	75	150	150	150	150	150	150
Time, hr.	2 + 4	2 + 4	2 + 4	2 + 4	2 + 4	2 + 4	2 + 4
1st-stage yield, %	87	...	...	...	...	...	...
			Stage 2				
Over-all yield, %	66.4	63.6	63.7	56.5	60	66.6	68.4
Lignin, %	32.9	35.3	32.0	26.3	33.2	32.6	32.9
Lignin removed, %	27.5	25	32	50.5	34	28	25
Nonlignin removed, %	36.5	41.3	38.3	40.5	42.5	36	34.5
			Stage 1				
Chemical	2% NaAc	50% Glycerine	Water	50% EtOH	10% HAC	5% NH_3	
Pressure, lb.	100	100	100	100	100	100	
Temperature, °C.	150	160	160	160	160	75	
Time, hr.	2 + 4	2 + 4	2 + 4	2 + 4	2 + 4	2 + 4	
1st-stage yield, %	...	81.8	...	...	72.6	...	
			Stage 2				
Over-all yield, %	65.4	64.5	67.9	58.9	66.1	63.8	
Lignin, %	29.6	33.7	36.8	25.6	39.8	32.5	
Lignin removed, %	35	28	17	50	12.5	31	
Nonlignin removed, %	34.5	39	39	37.5	43	38.5	

stages of the cook favors the initial conversion of lignin to an inactive form.

Table VI supplements Table II. Alkaline sodium sulphite as pretreat reagent results in better second-stage delignification than when sodium hydroxide is used alone, but removal of lignin falls far short of that obtained with sodium sulphite alone. On the other hand, the bisulphite pretreats are as beneficial as the unmodified sodium sulphite itself. In other words, the injurious effect of the free SO_2 is wholly offset and the bad influence of the sodium hydroxide pretreat is only partly offset by the sulphonating sulphite. At the elevated temperatures used, small percentages of additional free SO_2 beyond that present as bisulphite would very probably allow some of the undesirable reaction with the lignin that is regularly found with the weak SO_2 solutions.

Sodium sulphide resembles sodium hydroxide in that it renders the lignin relatively inert when applied at temperatures of 130°C. and higher. The addition of elemental sulphur to the sulphide has no apparent influence.

Speculation as to what basic conditions can cause wood lignin to become unreactive to sulphonating reagents led to a long series of experiments, some of which are given in Table VIII. The figures show

Table IX. Influence of Pretreatments on Delignification

Wood = western hemlock—40% H_2O content.
First-stage cook = digestion as indicated, x°C., 100 pounds applied pressure.
Second stage cook = digestion with 8–1 acid, 85 pounds maximum pressure, 140°C. maximum temperature, 4 + 4 hours.
All intermediate products washed.

				Stage 1					
Chemical	H_2O	H_2O	H_2O	1% NaOH	1% NaOH	1% NaOH	2% Na_2S	2% Na_2S	None
Temperature, °C.	130	150	170	75	100	130	130	150	
				Stage 2					
Over-all yield, %	42.8	47.8	64.3	49.4	50.6	64.5	71	72.6	44.9
Lignin, %	2.7	12	32.6	2.1	6.6	21.9	28.7	31.3	0.6
Lignin removed, %	96.2	81	30	96.5	89	53	32	24	99
Nonlignin removed, %	40	40	38	31	32.5	28	28	29	36.5

Table X. Influence of Pretreatments on Delignification

Wood = western hemlock—40% H_2O content.
First-stage cook = digestion as indicated, x°C., 100 pounds applied pressure.
Second-stage cook = digestion with 8–1 acid, 85 pounds maximum pressure, 140°C. maximum temperature, 4 + 4 hours.

				Stage 1						
Chemical	2% Na_2SO_3	2% Na_2SO_3	2% Na_2SO_3	1% NaOH 2% Na_2SO_3	1% free SO_2 1% comb. SO_2		1% free SO_2	1% free SO_2	None
Temperature, °C.	130	150	170	130	130	150	130	150	
				Stage 2					
Over-all yield, %	49.5	49.4	49.5	47.6	45.8	42.5	66.3	61.3	44.9
Lignin, %	0.5	0.5	0.8	7	0.74	0.68	38.5	44.2	0.6
Lignin removed, %	99.2	99.2	98.7	89	98.8	99.5	15	10	99
Nonlignin removed, %	30	30	30	37	35	40	42	51	36.5

Table XI. Comparison of Pretreat Influence

(Western Hemlock 3/4-inch chips)

Stage 1—130°C.; 2 + 4 hours; 100 pounds pressure. Stage 2—110°C.; 1 + 7.5 hours; 150 pounds pressure; 15% SO_2 solution.

Pretreat agent	*Yield, %*	*Lignin, %*	*Lignin removed, %*
Water	60	17.1	65.8
2% Na_2SO_3	50	0.86	98.5
1% NaOH	74	31.0	23.5
1% SO_2	67.2	39.7	11.5
5% SO_2	60.5	35.7	28.0
1% NaOH + 1% Na_2SO_3	61.4	20.1	59.0
1% free SO_2 + 1% comb. SO_2	47.7	1.3	97.9
2% Na_2S	63.5	30.2	36.5
None	49.9	9.9	83.9

Table XII. Comparison of Pretreat Influence

(Western Hemlock Wood)

Stage 1—130°C.; 2 + 4 hours; 100 pounds pressure. Stage 2A—110°C.; 1 + 7.5 hours; 150 pounds pressure; 15% SO_2 solution. Stage 2B—140°C.; 4 + 4 hours; 85 pounds pressure; 8–1 acid.

	2A			*2B*		
Pretreat agent	*Yield, %*	*Lignin, %*	*Lignin removed, %*	*Yield, %*	*Lignin, %*	*Lignin removed, %*
Water	60	17.1	65.8	42.8	2.7	96.2
2% Na_2SO_3	50	0.86	98.5	49.5	0.5	99.2
1% NaOH	74	31.0	23.5	64.5	21.9	53.0
1% free SO_2	67.2	39.7	11.5	66.3	38.5	15.0
1% NaOH + 1% Na_2SO_3	61.4	20.1	59.0	47.6	7.0	89.0
1% free SO_2 + 1% comb. SO_2	47.7	1.3	97.9	45.8	0.74	98.8
None	49.9	9.9	83.9	44.9	0.6	99.0

that except for limited protection found in the case of thiosulphate, other salts than sodium sulphite exert no beneficial influence. The alcohol solution is less injurious than water, and this was also found with aqueous mixtures of higher alcohols. Whether this can be explained by a lesser hydrolytic influence or by some antioxidant effect is not yet clear. Ammonia is particularly potent in converting the lignin to an inactive form. Profound changes can be brought about at temperatures as low as 75°C. The substituted ammonias have not yet been explored.

As already explained, all experiments shown through Table VIII were made with 15% SO_2 solution as the second-stage sulphonating agent. Tables IX and X cover experiments in which the second-stage digestion was carried out with bisulphite liquor containing 8% free SO_2 and 1% combined SO_2. In these particular second-stage treatments a maximum temperature of 140°C. was reached in 4 hours and that temperature was maintained for 4 hours. The relief was controlled to hold a maximum of 85 pounds gage pressure. In all cases the intermediate products were thoroughly washed before subjecting them to the bisulphite digestion. In comparing the results in Tables IX and X with those previously cited, it must be borne in mind that the comparison cooks, namely those made without a pretreat, show an appreciably more complete delignification in the case of the bisulphite digestion. Hence the lignin figures shown in the two-stage cooks must be interpreted in relation to the corresponding figures obtained with the respective comparison cooks. Even so, there appears to be ample evidence that the modified lignins are not as inert to the high temperature bisulphite digestion as found with the low temperature sulphurous acid cooks. Nevertheless, in all cases the various pretreatments interfere greatly with subsequent pulping. The relative influence of the various pretreat reagents used is substantially the same with the second-stage bisulphite digestion as found with the sulphurous acid cooks except in the case of the weak free SO_2 solutions. It is noteworthy that a 1% free SO_2 solution at temperature of 130°C. caused changes in lignin which result in the same high degree of resistance to subsequent sulphonation whether the second reagent be sulphurous acid itself or bisulphite applied at higher temperatures. This is particularly significant in view of the fact that low concentrations of SO_2 in contact with lignin are frequently probable during the early stages of normal pulping procedures.

Table XI shows in condensed form the relative influence of the various pretreat reagents used preceding the sulphurous acid digestions. All results are on a given pretreatment temperature basis, namely 130°C. Table XII shows a direct comparison of that pretreat influence on the sulphurous acid and the bisulphite digestions. As already mentioned, the case using 1% free SO_2 is outstanding in that subsequent delignification is very slight with both types of second-stage cook.

It is important to note whether a well-sulphonated lignin can be satisfactorily removed by subsequent hydrolysis with other acids than sulphurous. To throw further light on this question western hemlock wood chips were subjected to a pressure digestion at 130°C. with 20% sodium sulphite solution. As shown in Table XIII-A, the well-washed product had a lignin content of 32.9%. It contained 0.87% of bound sulphur. On a lignin basis the sulphur percentage can be expressed as 2.64.

Portions of the intermediate product were then digested in the various solutions shown in Table XIII-B. The results demonstrate that the sulphurous acid has specific properties. The stronger sulphuric acid is not suitable. The acetic acid serves in some degree. Water under the conditions tried effects only a limited delignification. Although not shown in the table, strong sulphite spent liquor from a normal pulping operation resembles the strong mineral acids and

Table XIIIA. Influence of 20% Na_2SO_3 Solution in Predigestion

Original Western Hemlock Wood—30.4% Lignin, 8.6% Pentosans, 0.05% Sodium, 0.02% Sulphur, and 0.33% Ash

First stage digestion:[a] 20% Na_2SO_3 solution, 35 pounds pressure, and 130°C.—1 + 6 hours

	Results		
Yield, %	86.9	Lignin removed, %	6
Lignin, %	32.9	Pentosans removed, %	61
Pentosans, %	3.9	Sulphur based on lignin, %	2.64
Ash, %	0.21		
Sodium, %	0.03	Sulphur based on carbon in lignin, %	4.1
Sulphur, %	0.87		

[a] Washing steps included two overnight soaks in large volume of fresh water, followed by an 8-hour soak in 5% HCl, followed by additional washings.

Table XIIIB. Second Stage Digestions

Intermediate Product from Table A was used in Sub-Portions for Second Digestion

Intermediate product tests: lignin = 32.9%; pentosans = 3.9%; sulphur = 0.87%.

Reagent	3% SO_2	6% SO_2	10% SO_2	15% SO_2	2% H_2SO_4	10% HAC	20% HAC	2% H_3PO_4	2% Phenol	2% Na_2CO_3	H_2O	6%[a] SO_2
Temperature, °C.	130	130	130	130	130	130	130	130	130	130	130	130
Time, hr.	1 + 6	1 + 6	1 + 6	1 + 6	1 + 6	1 + 6	1 + 6	1 + 6	1 + 6	1 + 6	1 + 6	1 + 6
Yield, % based on original wood	48.1	45	43	33	59.4	52	50	55	57	73.1	56	45
Lignin, %	4	1.5	0.7	0.6	34.7	14	10.5	21	21.5	34.1	18.5	15.3
Pentosans, %	1.6	1.6	1.2	0.7	...	1.9	2.1	1.3	1.8	...	1.9	1.0
Lignin removed based on lignin in intermediate product, %	93.2	97.6	99.0	99.3	33.5	74.6	81.7	59.5	57.2	13.0	64.0	76.0

[a] Intermediate product dried at 105°C.—3 hours, then digested in 6% SO_2.

causes only limited delignification. Experiments are under way to show whether the sulphonic and the sulphuric acids actually interfere with the normal reaction found with the sulphurous acid above if such strong acids are added to the sulphurous acid liquor. Other experiments will show whether higher concentrations of the weaker acids (acetic) can equal the results obtainable with sulphur dioxide. Some experiments in progress include cases in which the presulphonated wood is then exposed to a relatively weak sodium sulphite solution at higher temperatures than practiced in the first stage. If a major extraction of lignin can be so accomplished, it would lend some support to the conception that delignification is in fact explained by a progressive sulphonation which does not require sulphurous acid hydrolysis for completion.

Table XIV. Influence of Alkali and Free Acid in Presulphonation

	Stage 1		
Na_2SO_3, %	20	20	20
NaOH, %	0	1	0
Free SO_2, %	0	0	1
Temperature, °C.	130	130	130
Time, hr.	1 + 6	1 + 6	1 + 6
Ash, % (after washes)	0.23	0.27	0.35
	Stage 2		
Free SO_2, %	10	10	10
Temperature, °C.	130	130	130
Pressure, lb.	100	100	100
Time, hr.	1 + 6	1 + 6	1 + 6
Yield, %	36.4	35.9	37.1
Screenings, %	0.3	0.1	0.1
Pentosans, %	1.0	1.1	0.9
Lignin, %	0.9	7.2	0.8
Lignin removed, %	99	91.4	99

Table XIV comprises data from two-stage digestions in which the strong sodium sulphite solutions used for presulphonation were modified by the addition of 1% sodium hydroxide and 1% free SO_2, respectively. All second-stage treatments were carried out under favorable conditions and in the same manner. Results show that the presence of free alkali in the sulphite digestion is detrimental, although not to the same degree as experienced in the case of the weaker sodium sulphite solution cited in Table VI.

Wood lignin that has been rendered inert by high temperature treatments such as described above undergoes only minor if any reactivation when it is subjected to a second-stage digestion with sodium sulphite solutions at high temperatures prior to a third-stage digestion in sulphurous acid or bisulphite solution under conditions that readily pulp virgin wood. On the other hand, wood lignin that has been presulphonated with sodium sulphite solution retains most of its reactivity even though exposed to water at temperatures high enough to convert the original lignin to an inactive form.

Table XV and XVI comprise several three-stage sequences designed to illustrate both the protecting influence of a first stage sulphonation and the difficulty of reactivating a modified lignin after a first-stage polymerization. Comparison cooks are included. More work is under way particularly with 1% SO_2

Table XV. Influence of Pretreatments on Delignification

Wood = western hemlock—40% H_2O.
First two stages as indicated below.
Third stage = final digestion in 15% SO_2 solution, maximum pressure 150 pounds, maximum temperature 110°C., 1 + 7.5 hours.
Washing practiced between stages.

			Stage 1			
Chemical	2% Na_2SO_3	Water	2% Na_2SO_3		10% Na_2SO_3	
Pressure, lb.	100	100	100	None	100	None
Temperature, °C.	150	150	150		150	
Time, hr.	2 + 4	2 + 4	2 + 4		2 + 4	
			Stage 2			
Chemical	Water	2% Na_2SO_3	Water	Water	Water	
Pressure, lb.	100	100	100	100	100	
Temperature, °C.	150	150	170	170	170	None
Time, hr.	2 + 4	2 + 4	2 + 4	2 + 4	2 + 4	
			Stage 3			
Chemical	15% SO_2	15% SO_2	15% SO_2	15% SO_2	15% SO_2	15% SO_2
Yield, %	51.1	57.6	59.0	69.9	47.6	49.9
Lignin, %	2.68	28.5	18.8	38.1	1.9	9.93
Lignin removed, %	95.5	45	63	11	97	83.5

Table XVI. Influence of Pretreatments on Delignification

Wood = western hemlock—40% H_2O.
First two stages as indicated below.
Third stage = final digestion with 8–1 acid, temperature 140 °C., maximum pressure 85 pounds, 4 + 4 hours.
Washing practiced between stages.

				Stage 1				
Chemical		15% SO_2	15% SO_2	Water	10% Na_2SO_3	4 + 4[a]	Water	
Pressure, lb.	None	150	150	90	75	53	90	None
Temperature, °C.		110	110	160	160	135	160	
Time, hr.		2 + 4	2 + 4	2 + 2	2 + 2	2 + 3	2 + 2	
				Stage 2				
Chemical		Water	Water	15% SO_2	Water	Water		15% SO_2
Pressure, lb.	None	90	103	150	90	90	None	150
Temperature, °C.		160	170	110	160	160		110
Time, hr.		2 + 2	2 + 2	2 + 4	2 + 2	2 + 2		2 + 4
				Stage 3				
Chemical	8–1	8–1	8–1	8–1	8–1	8–1	8–1	8–1
Yield, %	44.9	39	33	63.6	49	44	55.2	44.5
Lignin, %	0.6	2.5	6.6	32	0.6	0.7	21	8.8
Lignin removed, %	99.1	96.8	92.7	32	98.4	99	61	87

[a] 4% free SO_2 + 4% combined SO_2.

solutions as digestants in the first or second stages.

In a single instance not shown in Table XV or Table XVI, a pretreatment of hemlock shavings with water at 160°C. followed by a sulphite digestion yielded an unpulped product that contained 0.9% bound sulphur. The second-stage product did not pulp in a third-stage cook under conditions that would ordinarily produce fiber. Other cooks of the same type are under way. First results indicate that a modified lignin can be sulphonated but that the sulphonated product does not respond to solubilization conditions that are present in acid sulphite pulping procedures.

Received Oct. 3, 1949. Presented at the Fall Meeting of the Technical Association of the Pulp & Paper Industry held at the Multnomah Hotel, Portland, Ore., Sept. 12–15, 1949.

Stream Pollution from Pulp Mills in Virginia

Applicability of the B.O.D. Test

A. H. PAESSLER and L. L. HEDGEPETH

The State Water Control Law is discussed briefly with a statement of its purpose and an explanation of the provisions it makes for controlling pollution. The status of municipal and industrial pollution is presented by means of maps showing the number of persons discharging treated and untreated sewage into each river basin, as well as the number and type of each industry discharging wastes. The pulp mill pollution problem is discussed. Use of the biochemical oxygen demand test is shown as one of a number of useful tools in determining the extent of this problem. It is stressed that factors other than B.O.D. are of equal or greater importance. The method of accomplishing pollution abatement does not usually concern regulatory agencies, but it is a matter of much concern to the mills. An example of the regulatory agency's conception of a typical pulp mill pollution problem is shown.

Stream pollution in Virginia is regulated under the State Water Control Law, enacted by the 1946 General Assembly, becoming effective July 1, 1946 (*1*). The law is administered by the State Water Control Board of five members appointed by the Governor under the authority of the law. This body determines policy and makes all final enforcement decisions. It is technically advised by the State Department of Health on sewage matters and by the Board's staff on industrial waste matters.

This law has these purposes: to safeguard clean waters from pollution, to prevent any increase in pollution, and to reduce that pollution existing when this law was adopted. These provisions are enforced by means of a permit system authorizing the discharge of wastes. Certificates for discharges of new wastes are issued only after appropriate measures have been provided to prevent stream pollution. Existing discharges are certificated as of July 1, 1946. The law declares the pollution of streams to be against public policy. Penalties are provided for violations of any section of the law, or for violating, failing, neglecting, or refusing to comply with any special final order of the Board. The law provides that pollution from existing sewage or industrial wastes shall be reduced as required by the Board. If the owner does not take the initiative to abate pollution from existing waste discharges, the Board may order him to do so, after a reasonable notice and hearing. On all new or expanded works for the treatment of old or new sanitary sewage, and on all expanded or new plants producing industrial wastes, the owners are required to secure Board approval and certification before construction is commenced.

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GENERAL POLLUTION PICTURE

At the end of 1948 the State had issued 440 certificates, 226 authorizing the discharge of sewage and 214 authorizing the discharge of industrial wastes. Figure 1 shows the number of persons discharging treated and raw sewage into each river basin. Sewage from 668,200 persons is discharged after treatment, while sewage from 1,002,300 persons is discharged without treatment.

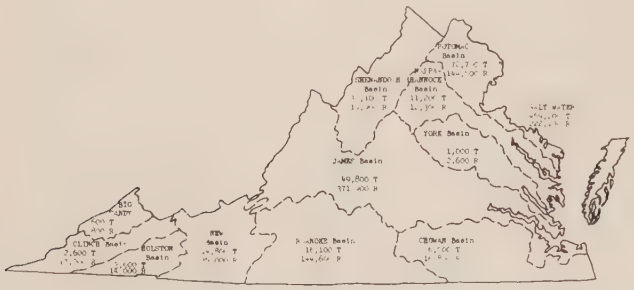

Fig. 1. Sewage discharges certificated by Virginia State Water Control Board at the end of 1948

Total, 668,200 T, 1,002,300 R. Figures Indicate Number of People Discharging. R = raw T = treated.

Figure 2 shows the number of each type of industrial waste discharged into the major river basins. The various types of industrial pollution are separately shown, without weighing, because it is not possible to state such discharges in terms directly comparable with each other, or with sanitary sewage. This is because there is no common denominator to use in comparing the types and intensities of the several industrial pollutants involved.

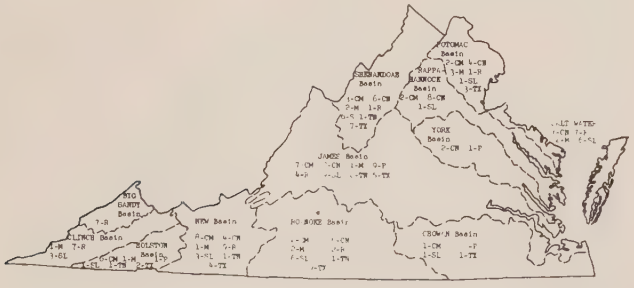

Fig. 2. Number and type of industrial waste discharges certificated by Virginia State Water Control Board by the end of 1948

CM = Chemical
CN = Cannery
F = Fish oil
M = Milk
P = Pulp and paper
R = Coal, or ore and stone washing
SL = Slaughterhouse or meat packing
TN = Tannery
TX = Textile

The locations and types of the nine pulp mills in Virginia are shown in Fig. 3. The heaviest pulp mill pollution is in the James River Basin which has five mills of the soda, sulphate, or semichemical pulp types. Sulphate pulp mills are also located on the York and Chowan Basins. An additional soda pulp mill is located on Beaver Creek in the Holston River Basin. A caustic pulp (building board) mill is located on the Nottoway River in the Chowan Basin.

While the James River and its tributaries receive the largest amount of pulp mill wastes, it is also a rather sizeable stream, but even so, it is dealt a successive number of blows from which it never fully recovers. Other mills are located on smaller streams which are unable to assimilate the pollution loads they receive except at normal stream flows.

The pulp mill pollution problem is one of the biggest, if not the biggest, of any industry in Virginia. It is characterized by massive discharges, the total pollutional extent of which has not yet been determined for the entire state. Determination of the stream pollution problem from a pulp mill involves many considerations, and some work along this line is being done, both by the Board and by industry.

APPLICABILITY OF THE B.O.D. TEST

The biochemical oxygen demand (B.O.D.) is only one of the effects exerted by industrial wastes on a stream. This test, while indicative of the relative intensity of the pollution, is not a high-precision method and, in the hands of the inexperienced, may give misleading results. When used under applicable

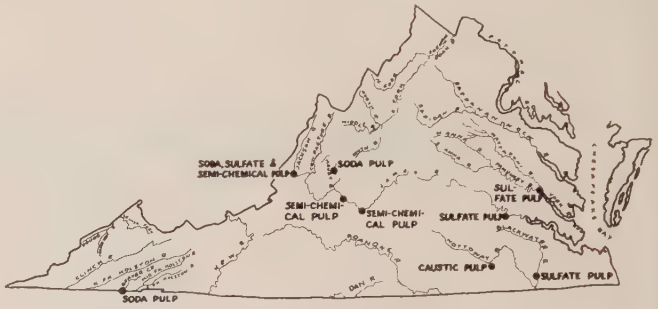

Fig. 3. Locations of Virginia pulp mills

conditions and in the hands of an experienced technician, it is an extremely useful device.

The sanitary sewage population equivalent resulting from the deoxygenating effects of industrial wastes may be approximated by the B.O.D. test. Toxicity, color, acidity, alkalinity, or salinity are not, however, directly or indirectly translatable into population equivalents. Nevertheless, they are of major importance in the industrial pollution problem. Thus the B.O.D., or population equivalents, do not alone depict the pollution contributions of industrial wastes. Further, they may not be applicable at all to certain types of wastes. For example, from one plant, the discharge of 110 tons per day of sulphuric acid does considerable damage to the receiving stream. This damage is not measurable by the B.O.D. test. The same holds true for a chemical plant daily discharging 1300 tons of inert chlorides into a small stream. Its wastes have no B.O.D., but the chloride concentration at times rises above that considered desirable in an environment which will support fresh-water fish life. While it is difficult to compare the pollution problem of one type of industry with that of another, comparisons between the problems of different plants in the same type of industry can usually be made. The wastes

from these plants will usually be similar and will be distinguished by certain characteristics, such as high B.O.D., or solids, or toxicity contents, from wastes of another type of industry.

The B.O.D. test is a laboratory measurement of the chemical oxygen demand and of the oxygen taken from the stream by the stream biota in breaking down organic matter contained in wastes discharged into it. Two identical bottles are each filled with a mixture containing known percentages of the waste sample and oxygenated water. They are then inoculated with microorganisms similar to those likely to be found in the stream into which the waste is discharged. The dissolved oxygen in one bottle is determined immediately; the other is incubated for 5 days at 20°C. and its dissolved oxygen determined. The difference in the amounts of dissolved oxygen at the beginning and end of the test represents the chemical demand plus that used by the microorganisms. The quotient obtained by dividing this amount by the decimal fraction of waste in the dilution is the B.O.D. of the sample (*2*). By the use of the factor of 0.17 pounds of 5-day B.O.D. oxygen as the deoxygenating load imposed on the receiving waters by the daily raw wastes from one person, the B.O.D. of an industrial waste may be expressed in terms of its population equivalent.

The test does not follow a simple chemical reaction whose formula may be written and from which stoichiometric predictions can be made. Depending on biological action, the speed and extent of oxidation in turn depends on the environmental conditions provided for the biological life. These are affected by the type of organic matter in the waste, the concentration of waste in the dilution bottle, the type of organisms inoculated into the dilution, the temperature of incubation, toxic materials in the dilution, the type of dilution water, pH, and by many other factors. For these reasons, one should not become alarmed when duplicate determinations on individual samples do not check. Instead of depending on high precision on one or a few samples, one must depend on many analyses made over a sufficiently long period of time to provide a dependable average.

The deficiencies of the B.O.D. test have been overemphasized by some; likewise, its importance has been overemphasized by others. Actually, these opposing viewpoints should not cause concern. There are other and more appropriate tests for arriving at the pollutional effect of industrial wastes and the B.O.D. test is not needed except where it is specifically applicable.

In a pulp mill the pollution problem, as was mentioned previously, is more than one of B.O.D. Fiber loss, solids, both suspended and dissolved, alkalies, color, and toxicity are important and are measurable by known and relatively precise chemical or physical tests.

DETERMINING PULP MILL POLLUTION

Getting the complete pollution picture involves entirely different approaches by mill and regulatory agencies. The regulatory body will normally be interested in only one thing: the volume and analysis of the waste discharged into a stream and its effect on the stream. The mill will want not only this figure, but a breakdown showing where the various components of the waste originate, and their analyses. This requires making a detailed study of the mill's operation and tracing on a flowsheet courses of the various materials and their ultimate disposition. The regulatory body will review the figures on the composition of the final effluent and determine if a reduction of pollution should be made. How such a reduction is accomplished is normally not the concern of such an agency. That is, if it is accomplished either through process control in the plant, or by a treatment plant on the end of the mill sewer, the load has been reduced. This is, after all, the regulatory objective. But the method employed does make a difference to the mill.

Process recovery methods present the possibility of some financial return, or saving from the sale of by-products or return to process of some chemical. On the other hand, constructing and operating a treatment plant on the end of the sewer is usually a red-ink operation.

Therefore, the mill should make a critical study of its flowsheet to determine the nature and composition of all the component parts of the composite waste with the idea in mind of cutting out or reducing the amount of waste produced at each point if recovery methods are not feasible. By these means, the cost of pollution abatement is substantially reduced.

An example of a regulatory consideration of the waste problem of a typical southern kraft pulp mill is shown in Fig. 4. This depicts our conception of the problem of the Camp Manufacturing Co. at Franklin, Va. It is seen at a glance that by process control and special effluent treatment, that the B.O.D. load on the stream has been reduced to 8000 population equivalent for each 100 tons of wood taken into the mill. From a more detailed flowsheet a pulp mill's waste disposal man may determine the various steps to be taken in reducing or eliminating waste within his plant.

The stream pollution problem presented by this example is one primarily of B.O.D. The lagoons, which also receive paper mill white water, remove substantially all settleable solids, while reducing the color, B.O.D., and total solids through biological action to a point where they can be assimilated during

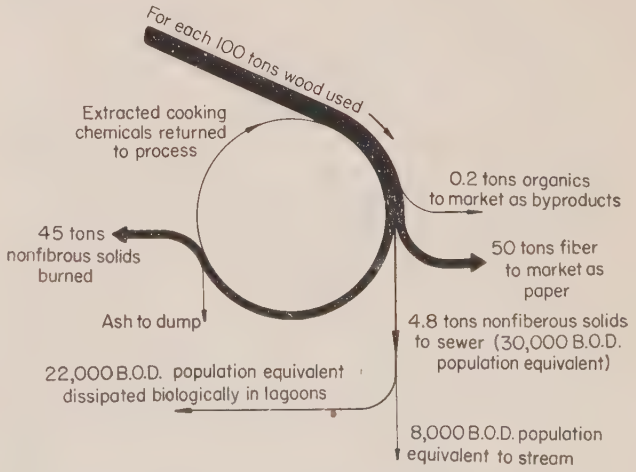
For each 100 tons wood used
Extracted cooking chemicals returned to process
0.2 tons organics to market as byproducts
45 tons nonfibrous solids burned
50 tons fiber to market as paper
Ash to dump
4.8 tons nonfiberous solids to sewer (30,000 B.O.D. population equivalent)
22,000 B.O.D. population equivalent dissipated biologically in lagoons
8,000 B.O.D. population equivalent to stream

Fig. 4. Simplified consideration for stream pollution problem of a southern kraft mill

normal flows of the Blackwater River. The B.O.D. figures represent averages obtained from analyses accumulated over a sufficiently long period of time to smooth out errors in technique and inherent errors in the B.O.D. test.

Through a systematic attack of the problem, this mill has reduced its stream pollution to a point where the Blackwater River remains healthy during all but extremely low flows. Through process changes and improvements in ponding, a further reduction in the B.O.D. load on the river is expected.

This example represents one way in which results obtained from use of the B.O.D. test can be made to mean something and can be depended on to be reliable. A materials balance is essential to check the information yielded by the B.O.D. data. Comparison of B.O.D. results with the simple stoichiometric amount of oxygen required in oxidation of a waste containing essentially a single compound, for example acetic acid, will give a means of checking results. In the absence of complications, a result varying greatly from the theoretical value would indicate faulty B.O.D. technique, and the cause for the discrepancy should be investigated. Sometimes the fault is not in the technique, however. Formaldehyde, for instance, will consistently show B.O.D. values twice that of the amount required in its oxidation. Similarly, oxalic acid, which exerts an oxygen demand on the stream, has no B.O.D.

Though much remains to be done toward solving the pulp mill pollution problem in Virginia, a good start has been made. The mills are, for the most part, each studying their individual part of it, either in their own laboratories or in cooperation with the National Council for Stream Improvement and similar agencies. This work will lead finally to a delineation of the problem. Having determined its nature and extent in each case, there is hope that substantial abatement can be secured through plant control, process recovery, or external treatment methods.

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Received Jan. 28, 1949. Presented at the Annual Meeting of the Technical Association of the Pulp & Paper Industry, Hotel Commodore, New York, N. Y. Feb 21–24, 1949.

DISCUSSION

Stuart C. Crawford (Consulting Chemist, Franklin, Va.) My comments on the foregoing paper may more properly be construed as emphasizing the importance of mill survey work in the over-all attack on pulp mill pollution problems than as a discussion of the contents of this paper. As Mr. Paessler has brought out "Process recovery methods at least present the possibility of some financial return or saving from the sale of byproducts or return to process of some chemical, while constructing and operating a treatment plant on the end of the sewer is usually a red-ink operation." Almost universally the costs of engaging in pollution abatement work are regarded as "burden expenses" and such work is only considered from a public relations standpoint. This is, in my opinion, oftentimes the cause why no more abatement is accomplished when stream pollution is added to the multitude of problems already confronting the average mill laboratory. Such personnel must of necessity be primarily interested in production, not losses, while the essential consideration in any abatement program must be the losses, not production. The industrial wastes specialist must carry the information concerning these losses to the pulp and papermaking specialists and in so doing he becomes a contributing member of the organization. However, his most significant contribution results from the basic difference of approach in that losses are examined for their component part in the over-all pollution problem rather than as material losses.

Such has been the procedure followed at the Camp Manufacturing Co.'s mill at Franklin, Va. Through a concurrent program of mill survey work and the development of abatement methods the accomplishments outlined in the example cited have been achieved and serve as a basis for future developments. This work at Franklin has been reported in the literature previously so only a brief summary is offered at this time to show a relationship between process recovery methods and external treatment.

Summary—Camp Manufacturing Co., Franklin, Va.

1. Of the 70 to 75% over-all reduction in the total mill B.O.D. load to the river, 20 to 25% resulted from improvements within the mill.
2. The total suspended solids loss from mill operations has been decreased by more than $^1/_3$ since 1943. The actual loss to the river is currently below 0.15 pounds per 1000 gallons.
3. Corresponding reductions in other undesirable characteristics of the wastes such as dissolved solids, color, and odor have resulted.

Further, the present approach is that mill operations serve as the limiting factor to the efficiency of the external treatment system. Therefore, the object is that of continually reducing losses within the mill as a means of further cutting the load to the stream.

Another example of such an approach is that of the National Container Corp. of Virginia located at Big Island, Va. In comparing 1948 conditions with those existing during 1947 it is found:

1. The total pollution load from mill operations was decreased 10% in spite of a production increase of approximately 7%.
2. With the installation of a partial treatment area, to be expanded this year, the lowest individual D.O. test recorded during 1948 was 4.5 p.p.m. as compared with 1.1 p.p.m. recorded in 1947. River flow during the two periods was comparable.

The above examples are cited as indicative of what is being accomplished in Virginia under the existing laws. Undoubtedly there are other examples. Such programs require what might be termed "double" cooperation. Not only must there be the cooperation between mill and regulatory authority which has been so publicized but also a cooperative understanding within the mill between the production personnel and those responsible for the abatement of the problem is imperative if the program is to succeed.

The Relation of Kraft Pulp Qualities to the Wood Properties of Douglas Fir

R. N. HAMMOND and P. S. BILLINGTON

Douglas fir logs in the following growth classes were selected and evaluated: 350-year old slow growth; old rapid growth heartwood (plywood veneer cores); 95-year old rapid growth; 85-year old slow growth; 50-year old medium growth; 40-year old slow growth; 30-year old rapid growth. The samples were evaluated as to average rate of growth, percentages of bark, sapwood, springwood, wood density, and chip density. The woods were all cooked identically to give pulps of from 14 to 17 TAPPI permanganate numbers. The yields varied roughly with the percentage of sapwood. Burst, fold, and sheet density varied directly with the percentage of springwood, and the tearing strength inversely so. The per cent alpha-cellulose was definitely lower in the pulps from the woods younger than 85 years old. The young woods produced pulps which bleached to a higher brightness under the same bleaching conditions, but also suffered slightly more strength degradation in bleaching.

THE USE of Douglas fir wood in the production of sulphate pulp is becoming more general in the Pacific Northwest. The efforts of the lumber and pulp producers to more completely utilize the products of the forest and to maintain them on a permanent tree-farm basis has led to the increased use of small understory trees from mature stands through the prelogging, or relogging of the area to recover this wood that was formerly wasted. Improved hydraulic barking methods produce slab and mill waste wood of high quality which has resulted in this waste being diverted from the trash burner to profitable use in the pulp mill with the result that wood from diverse age classes and growing conditions is being used for pulp. The yield and quality of sulphate pulp obtained from the different types of Douglas fir timber have been the subject of considerable discussion. This paper is a report of an investigation of the yield, and chemical and physical properties of sulphate pulps obtained under controlled pulping and bleaching conditions, as related to the physical properties of Douglas fir represented by seven types of wood.

The timber was obtained from the mountainous area in eastern Cowlitz County in the State of Washington. Since the wood source was from the Cascade Mountains the results may not directly apply to Douglas fir grown under widely different conditions, as in the coast fog belt or intermountain areas.

The seven lots of wood chosen for evaluation represent wide practical variations in age and rate of growth from the Cascade Mountains area. In general, they represent old growth Douglas fir, prelogged trees or thinnings from either old or second growth stands, and mature second growth. All wood lots were selected to contain only sound wood.

Each type of wood was evaluated for age, size, rate of growth, per cent bark, per cent sapwood, moisture content, and density; and together with density, the related property of per cent springwood and summerwood. The pulp from each type of wood was chemically evaluated in both the unbleached and bleached condition for per cent alpha cellulose and solution viscosity, and in the bleached condition for copper number and per cent solubility in 10% KOH. Pulps in both conditions were formed into dried sheets, and physically evaluated by beating and testing for freeness, burst, tear, fold, and sheet density.

THE TYPES OF WOOD STUDIED

The following summary describes the wood included in each classification studied:

Old Growth

A 350-year old log, 38 inches in diameter inside the bark, with a growth rate from 3 to 45 annual rings per inch and a weighted average growth rate of 25.5 rings per inch.

Old Rapid Growth

Thirteen veneer core blocks, 9 to 12 inches in diameter, with 2 to 13 annual rings per inch and a weighted average growth rate of 6.2 rings per inch.

Young Rapid Growth

Four 30-year old trees, 12 to 14 inches in diameter outside the bark, with 2 to 9 annual rings per inch and a weighted average growth rate of 4.1 rings per inch.

Young Slow Growth

Seven 44-year old trees, 7 to 11 inches in diameter outside the bark, with 4 to 16 annual rings per inch and a weighted average growth rate of 11.7 rings per inch.

Young Average Growth

Three 51-year old trees, 11 to 19 inches in diameter outside the bark, with 3 to 21 annual rings per inch and a weighted average growth rate of 8.6 rings per inch.

85-Year Old Mature Second Growth

An 85-year old tree, 19 inches in diameter outside the bark, with 6 to 22 annual rings per inch and a weighted average growth rate of 10.3 rings per inch.

95-Year Old Mature Second Growth

A butt log, 27 inches in diameter inside the bark,

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with 3 to 14 annual rings per inch and a weighted average growth rate of 7.4 rings per inch.

The trees used for the 30, 44, 51, and 85-year old lots were cut to a minimum top diameter of 4 inches inside the bark, and approximately 75 cubic feet of solid wood from each lot was put through a commercial mill chipper. All except the 95-year old log were chipped on a four-knife 72-inch Sumner chipper, and screened. The 95-year old log was chipped on a four-knife 175-inch whole log chipper and the chips used without screening.

EVALUATION OF WOOD SAMPLES

Previous to chipping each lot, representative wood cross sections were obtained for physical evaluation of the wood. Figures 1 and 2 show the appearance from the pith to the bark of the tree of typical segments of wood sections from the 30-year old and the 350-year old groups.

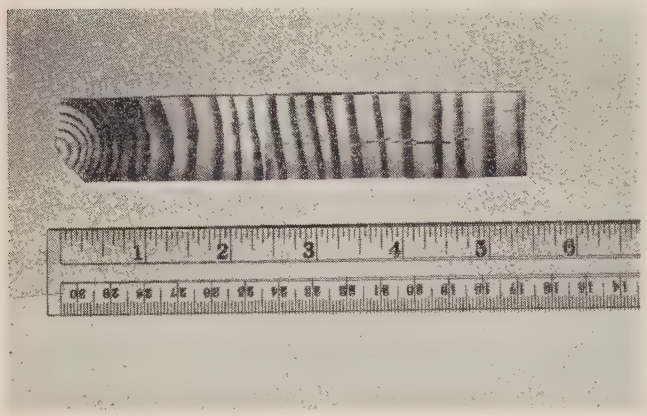

Fig. 1. 30-yr. old Douglas fir cross section, pith to bark

Table I summarizes the physical properties of the Douglas fir from each lot of wood.

Age and Growth Rate

The tree ages were determined by annual ring count in the woods and the log ages estimated from a ring count of the butt logs. The veneer core blocks were obtained from the plywood mill and represent the cores of old growth trees in the 200 to 400-year age class. The weighted average rings per inch, or growth rate, for each lot of wood was obtained from annual rings per inch measurements of each cross-section sample by inch increments from the pith to the bark. The measurements were weighted and averaged according to the volume of wood present at the various distances from the center of the log.

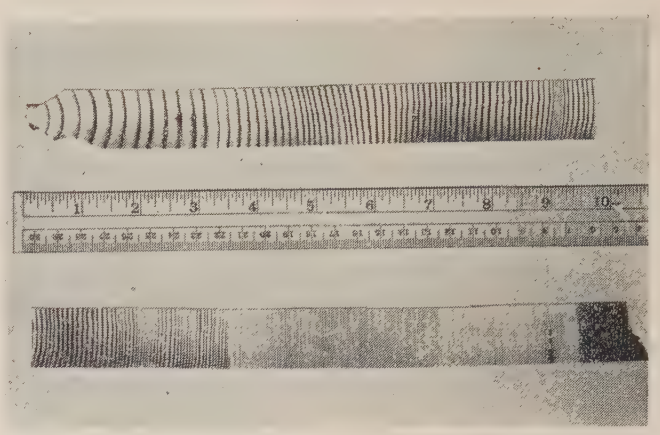

Fig. 2. 350-yr. old Douglas fir cross section, pith to bark

Bark

There is an increasing tendency in log handling operations to weigh truck loads of wood instead of scaling log volumes, hence the per cent bark of the green samples was recorded as of being of interest in this respect. The bark ranged from 11.6 to 16.2% of the total unbarked weight of the log, with an average value for all types of Douglas fir of approximately 15%. There was no correlation with log size or age. The amount or per cent of moisture-free wood available on a total bark plus green wood weight basis, however, is less in the young Douglas fir logs than in the older, larger logs, because of the higher percentage of sapwood and resulting higher moisture content in the young trees. The following percentage breakdown for the 30-year old wood lot and the 350-year old log illustrates this relationship:

Table I. Summary of Wood Data

Group designation	*350-yr. old growth log*	*Rapid old growth boxed hearts*	*30-yr. old rapid growth*	*40-yr. old slow growth*	*50-yr. old average thinnings*	*85-yr. old slow growth*	*95-yr. old rapid growth*
Number trees	1-log	13 cores	4	7	3	1	1-log
Stump diameter outside bark, in.	38[a]	9 to 12[a]	12 to 14	7 to 11	11 to 19	19	27[a]
Average age, yr.	350	Old Logs	30	44	51	85	95
Weighted av. rings/inch	25.5	6.2	4.1	11.7	8.6	10.3	7.4
Per cent bark of green weight	15.8	0	15.0	14.6	14.7	16.2	11.6
Weighted av. % sapwood by volume	15.2	0	65.8	49.3	46.7	40.8	27.8
Average sapwood width in inches	1.5	0	2.25	1.0	1.25	1.75	2.25
Sapwood, moisture-free, %	34.7	..	42.2	47.8	37.5	43.2	41.2
Heartwood, moisture-free, %	74.4	71.9	71.6	74.8	73.3	73.5	71.7
Weighted average Moisture-free wholewood, %	67.3	71.9	50.3	58.1	51.0	56.7	60.1
Density,[b] sapwood	0.382	..	0.403	0.466	0.414	0.468	0.426
Density, heartwood	0.400	0.389	0.391	0.418	0.392	0.438	0.411
Weighted average density wholewood	0.398	0.389	0.397	0.435	0.399	0.467	0.415
Moisture-free lb./cu. ft.	24.8	24.3	24.8	27.2	24.9	29.2	25.9
Calculated % springwood by weight	46.7	49.5	47.0	36.6	46.4	29.1	41.9
Chips, moisture-free lb./cu. ft.	9.66	10.03	9.87	10.40	10.02	11.18	10.26[c]

[a] Actual log or core diameter.
[b] Densities are based on moisture-free weight and green volume.
[c] Unscreened chips.

	Percentages of total green weight of logs		
	Bark, %	Wood moisture, %	Moisture-free wood, %
30-year old	15.0	42.2	42.8
350-year old	15.8	27.5	56.7

Sapwood and Heartwood

The per cent by volume of sapwood is recorded for each class of wood, being zero for the veneer core blocks, 15.2% for the 350-year old log, and 65.8% for the 30-year old wood. The average width of the sapwood is also shown for each lot. The per cent sapwood by weight was generally slightly greater than the per cent by volume as the sapwood density was higher than the heartwood density except for the 350-year old log where the reverse was true. In general, Douglas fir trees of uniform growth rate show an increasing density of wood from the pith toward the bark. However, in very old trees, such as the 350-year old growth herein recorded, the outer few inches of wood show a drop in density, illustrating the decadence occuring in over-aged timber.

Wood Moisture

The per cent of moisture-free wood in both the sapwood and heartwood portions of the various lots of wood is also shown in Table I. The sapwood has a much higher moisture content, the average value for all lots being 59% while the heartwood averaged 27% moisture, all moisture values being expressed on a green wood weight basis. The weighted average values for per cent moisture-free and density of the "whole wood" from the various lots are average values representing all the wood on a proportional volumetric basis. Measurements for each sample were made in some cases on a complete cross section, and in others on a pie-shaped segment representing, proportionately, the volume of the log. The results for each sample from a given lot of wood were then weighted in proportion to the volume of the sampled log. The per cent moisture-free wood in each lot is representative of the relative amounts of sapwood and heartwood present.

Wood Density

The wood density, based on green volume and moisture-free weight, is shown in grams per cubic centimeter for the sapwood, heartwood, and wholewood. The density values were obtained by the water displacement method (TAPPI T 18 m-47). The weighted averaged values for each lot are shown in Table I, as pounds of moisture-free wood per cubic foot, green basis. These average values ranged from 24.3 for the veneer core blocks to 29.2 pounds per cubic foot for the 85-year old wood. There is no correlation between the number of rings per inch, or growth rate, and the moisture-free wood weight per cubic foot.

Springwood and Summerwood

The springwood is designated by the light colored soft portion of each annual ring in Douglas fir as shown in Figs. 1 and 2, and has been found to produce pulp of markedly different properties than the summerwood or hard, dark colored portion of the annual ring. It seemed desirable to obtain values for the distribution of springwood and summerwood in the wood classes used in this study. A method of correlating these values with wood density has been worked out, as subsequently indicated, and the calculated values for the per cent springwood by weight for each lot of wood are shown in Table I. These varied from 29.1% for the dense 85-year old wood to 49.5% for the veneer cores.

The relationship between wood density and per cent springwood and summerwood was determined from ten sawn block samples of wood with densities from 0.326 to 0.487 and growth rates from $3^1/_2$ to 33 annual rings per inch. These samples were chosen from several of the lots of wood to give the widest possible range of densities and growth rates. The percentages of springwood for eight of the samples were determined by photographing the green smooth cross sections at approximately 2× magnification, cutting apart the springwood and summerwood portions of the photographs with scissors, and weighing the accumulated cut pieces. The relative weights of the springwood and summerwood portion of each photograph gives a direct measurement of the volume percentage of each type of wood. Two samples with over 30 rings per inch were measured with a microscope using a ruled eyepiece disk. Figure 3 shows the per cent

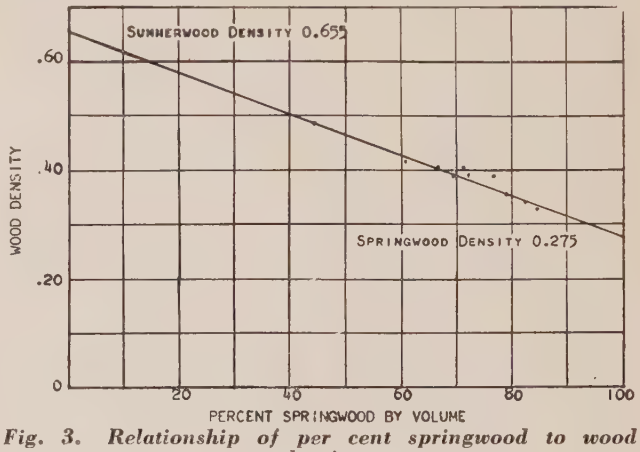

Fig. 3. Relationship of per cent springwood to wood density

springwood plotted against the wood density values for the samples. A straight line was drawn through the points and extended to 0 and 100% springwood. Extrapolation of the density value to 0% springwood gives 0.655 as the average density of the summerwood portion of these Douglas fir samples. The 100% springwood point gives 0.275 as the density of springwood. Table II shows the growth rates of the wood block samples, their measured densities, the percentage of springwood found, and the method of measurement. The density of each sample is shown as calculated from the measured per cent springwood and summerwood and their extrapolated densities. The last column shows the per cent deviation of the calculated density figures from the measured values, the maximum variation being from +2.5 to −6.2%. Table III shows the average per cent springwood by volume and by weight for the various lots of wood as calculated from their average densities. Included with the table is the method of calculation of these values for any Douglas fir wood density values based on moisture-free weight and green wood volume. The devia-

Table II. Tabulation of Individual Springwood-Summerwood and Density Determinations

Type of wood sample source	*Rings per inch*	*Measured density*	*Springwood by volume, %*	*Method of measurement*	*Calculated density*	*Per cent deviation of calculated density from measured*
50-yr. old	$3^1/_2$	0.341	82.54	Photograph	0.341	0
Old growth	4	0.326	84.39	Photograph	0.334	+2.5
85-yr. old	5	0.406	66.72	Photograph	0.401	−1.2
85-yr. old	7	0.415	60.82	Photograph	0.424	+2.1
Old growth	7	0.354	78.99	Photograph	0.355	+0.3
Old growth	9	0.388	76.60	Photograph	0.364	−6.2
50-yr. old	10	0.388	69.84	Photograph	0.390	+0.5
85-yr. old	11	0.487	44.06	Photograph	0.488	+0.2
Old growth	32	0.406	71.33	Microscope	0.384	−5.4
Old growth[a]	33	0.390	72.15	Microscope	0.381	−2.3

[a] Sample dry when measured, all others measured when wet.
Graphically extrapolated densities: Springwood = 0.275; Summerwood = 0.655.
Densities based on green volume and moisture-free weight.

tion and general applicability of springwood and summerwood density values in Douglas fir are not known and depend on further experimental verification.

Chip Density

As each lot of wood was chipped it was placed in a closed chip bin with moisture barrier walls to maintain wood-moisture content during storage. Storage time previous to pulping was held to a minimum. The pounds of chips per cubic foot of the chipped wood from each lot is also shown in Table I. These values are based on settled green chip volume and moisture-free weight, ranging from 9.66 to 11.18 pounds per cubic foot. The values were obtained from settled chips measured in a calibrated cylindrical vessel of approximately 1 cubic foot capacity.

PULPING, AND QUALITIES OF THE UNBLEACHED PULPS

The digestions were made in a 40-cubic foot stainless-alloy digester equipped for circulation, and both direct and indirect heating. The chips were weighed into the digester, being sampled during handling. The moisture contents of the chip samples were determined previous to pulping to permit control of the chemical to wood ratio in the digester. The pulp was blown under 80 p.s.i. pressure to a screen-bottom blow pit. After washing, the pulp was screened through 10-cut screen plates and the yield determined on the screened stock. In all cases the cooking conditions were as follows:

Liquor:
- Active alkali ..... 16% (based on moisture-free wood) as Na_2O
- Sulphidity ..... 25% (of active alkali) as Na_2O
- Liquor-wood ratio ..... 3.5 (Total liquor including moisture in the chips).

Temperature:
- 2 hours linear rise to 172°C. (341.6°F.)
- 2 hours at 172°C.
- $^1/_4$ hour blowdown to 80 p.s.i. pressure
- $4^1/_4$ hours total time

The liquor was continuously circulated throughout the duration of the digestion and was steam heated indirectly in a heat exchanger.

The screened pulps were dried after forming into sheets, and strength evaluations were made on these dried pulps rather than on the slush or wet stock. The pulps were beaten in a $1^1/_2$ pound Valley test beater according to TAPPI Standards T 200 m-40, and the sheets were formed on British sheetmaking equipment in accordance with TAPPI Standards T 205 m-47. Freeness results are Schopper-Riegler values, and fold tests were made on the M.I.T. tester. The detailed evaluation data on each cook are given in Table IV. With the exception of the 95-year old sample all cooks were made in duplicate. The pertinent data of this table, together with some of the wood evaluation data, are represented in Fig. 4.

The following discussion brings out the salient features of Table IV and Fig. 4:

Yields and Chemical Analyses

Since the digestion conditions were all identical the bleachability range was very narrow. The TAPPI permanganate numbers varied from 13.9 to 17.5, and showed no correlation with wood properties.

In general the pulp yields from old woods were definitely lower than those from young woods. The former gave yields of 41.75 to 42.25% while the yields from the latter were 43.75 to 45.50%. The yield appeared to be rather heavily influenced by the percentage of heartwood—thus the highest heartwood sample gave the lowest pulp yield, and the lowest heartwood sample gave the highest yield. The intermediate values followed roughly in the same pattern.

The very young woods (up to 50 years of age) gave pulps of markedly lower alpha-cellulose, 93% and lower as compared with 94% for the older woods. It should be noted that these unbleached alpha-cellulose values are used as indices only since no correction was made for the lignin content of the pulps. How-

Table III. Weighted Average Springwood-Summerwood Percentage Calculations

Density Springwood = 0.275; Density Springwood = 0.655

Wood lot	*Weighted average density*	*Springwood by volume, %*	*Springwood by weight, %*
Old growth log	0.398	67.63	46.72
Veneer cores	0.389	70.00	49.49
30-year old	0.397	67.89	47.03
40-year old	0.435	57.89	36.60
50-year old	0.399	67.37	46.43
85-year old	0.467	49.47	29.13
95-year old	0.415	63.16	41.85

X = per cent by volume of springwood
Y = per cent by volume of summerwood
$$X = \frac{65.5 - 100D}{0.38}$$

$X + Y = 100\%$ of volume
$$Y = 100 - X$$

D = density of Douglas fir[a]
W = per cent of springwood by weight
$$W = \frac{0.275\,X}{D}$$

[a] Based on moisture-free weight and green volume.

ever, they serve very well in this respect because of the uniform permanganate numbers of the unbleached pulps. No close correlation of alpha-cellulose to wood properties seems possible except to indicate that the three lowest heartwood samples produced pulps of the lowest alpha-cellulose content.

Physical Qualities

The comparative strength evaluations were all made on pulps beaten to 550 S-R freeness. In beating time the only outstanding pulp was that from the old growth whole log which was by far the slowest growing sample studied. Its pulp beating time was 176 minutes as compared with a maximum beating time of about 120 minutes for the younger woods, the shortest beating time being 110 minutes for the pulp from the 40-year old wood lot.

From the physical structure of the springwood and summerwood fibers of Douglas fir a close correlation between bursting strength and percentage of springwood is to be expected. That this was borne out is seen from Fig. 4. There was apparently also an "age influence" in this relationship. Of the two old age woods, the one with the higher springwood gave a pulp of 5 points higher burst. This same pattern was followed in the cases of the three youngest samples. It was reversed in the 85 to 95 year old range. It was also noticeable that in the cases of the very young group the same percentages of springwood gave pulps of appreciably higher bursting strengths than were obtained in the old age group. Thus, the pulp from the 30-year old wood gave 10 points higher burst than that from the 350-year old wood.

The initial bursting strengths roughly followed the per cent of springwood, with allowance made for the wood age effect. The pulp from the 85-year old wood lot with 29.1% of springwood had an initial burst of 28 as compared with a 48 initial burst for the pulp from the 50-year old wood containing 46.4% springwood.

The tearing strengths generally followed the reverse pattern of the bursting strengths, the pulps of highest burst giving the lowest tearing strengths.

The folding strengths fell into line with the other strength properties, in general paralleling the bursting strength values. The folds ranged from 850 to 1500 double folds. As seen in Fig. 4, the fold values changed almost identically with the changes in per cent of springwood in the various wood classes.

Table IV. Yields and Qualities of Unbleached Pulps

Wood	*Cook No.*	*Moisture-free wood chg'd, lb.*	*Wood moisture-free, %*	*Screened yield, %*	*Screenings, %*	*TAPPI $KMnO_4$ No.*	*Alpha-cellulose, %*	*Viscosity[a] CED 1%, cp.*	*Beating time to 550 freeness, min.*	*Initial bursting strength*	*At 550 freeness*			
											Bursting strength	*Tear*	*Fold*	*Sheet density*
350-yr. Whole log	1862	299	73.30	42.19	0.23	14.90	94.0	287	175	30	171	4.05	1350	0.62
	1863	296	72.94	42.27	0.14	15.37	93.9	334	178	31	177	4.20	1520	0.63
Old age Veneer cores	1860	290	76.44	42.06	0.55	13.90	93.8	427	135	33	178	3.20	1450	0.66
	1861	298	75.94	41.40	0.93	14.90	94.0	411	140	36	180	3.15	1440	0.66
95-yr. old rapid growth	1876	304	63.80	43.77	0.35	14.90	94.0	429	125	36	151	4.10	1050	0.62
85-yr. old slow growth	1850	344	68.05	45.35	0.28	16.58	94.2	643	130	28	163	3.70	860	0.60
	1851	313	69.30	44.70	0.28	16.48	94.1	536	120	28	159	3.80	860	0.59
50-yr. old medium growth	1854	282	62.85	43.96	0.77	15.70	92.9	361	130	51	192	3.10	1370	0.65
	1857	302	64.20	43.65	0.30	17.50	93.1	459	115	45	185	3.20	1360	0.64
40-yr. old slow growth	1871	285	57.00	45.63	0.49	15.24	92.5	350	110	37	183	3.05	1250	0.67
	1872	319	58.15	45.03	0.37	14.33	92.8	303	110	36	184	3.05	1230	0.67
30-yr. old rapid growth	1866	304	49.38	45.00	0.29	14.70	92.4	300	112	40	187	2.80	1460	0.68
	1867	286	47.66	45.92	0.42	16.40	92.7	411	120	42	182	2.65	1530	0.69

[a] 0.5*N* Cupriethylenediamine solution containing 1% moisture-free cellulose.

The pulp test sheet density at 550 freeness also followed rather closely the percentages of springwood. The correlation between the density and expected strengths was well in line with the exception of the reversal of comparative bursting and tear strengths in the 85 to 95-year old groups.

BLEACHING, AND QUALITIES OF THE BLEACHED PULPS

Portions of the pulp from one cook of each of the various age samples were bleached under several different conditions of chemical-to-pulp ratios in a six-stage procedure to give varying degrees of brightness. The conditions under which all the pulps gave maximum brightness without excessive degradation were:

1st stage chlorination..... Cl_2 = 28.8% of $KMnO_4$ No.
2nd stage neutralization..... NaOH = 0.5% of pulp
3rd stage bleach..... Cl_2 (as hypochlor.) = 37% of chlorinated $KMnO_4$ No.
NaOH = 0.75% of pulp
12% consistency, 30°C., 1.5 hours
4th stage caustic extraction.... NaOH = 2% of pulp
14% consistency, 65°C., 1 hour
5th stage bleach..... Cl_2 (as hypochlor.) = 1% of pulp
NaOH = 0.25% of pulp
16% consistency, 32°C., 3.5 hours
6th stage SO_2..... Flash treatment

Table V. Qualities of Bleached Pulps

Wood	*Cook No.*	*Bleach No.*	*Brightness*	*Alpha-cellulose, %*	*Cu No.*	*10% KOH solubility, %*	*Viscosity CED 1%, cp.*	*Beating time to 550 freeness, min.*	*Initial bursting strength*	*At 550 freeness*			
										Bursting strength	*Tear*	*Fold*	*Sheet density*
350-yr. old	1862	2873	86.5	92.3	0.96	14.7	29	102	39	161	2.50	660	0.63
Veneer cores	1860	2866	86.7	92.9	0.76	11.5	37	97	27	170	2.30	960	0.67
95-yr. old	1876	2892	86.5	92.1	0.75	13.0	36	102	30	147	2.80	610	0.62
85-yr. old	1850	2846	87.4	91.9	0.88	16.3	33	84	32	152	2.75	460	0.61
50-yr. old	1854	2855	88.6	90.3	1.06	16.9	34	78	48	177	2.25	820	0.66
40-yr. old	1871	2884	89.0	90.0	0.92	16.0	32	81	38	176	2.10	760	0.68
30-yr. old	1866	2879	89.0	89.6	1.20	17.5	32	82	38	170	1.95	720	0.69

The comparative chemical analyses and strength data on these pulps are given in Table V, the pertinent data of which are graphically represented in Fig. 4.

Brightness

For brightness evaluation a sample of the bleached pulp was formed into uniform sheets. The complete spectrophotometric reflectance curve was determined on the dried pulp sheet with a General Electric Recording Spectrophotometer and referred to MgO as the basic standard. The values at the 458 mmu wavelength ordinate are reported as the brightness values.

Strength Qualities

The beating time, burst, tear, fold and sheet density all followed the same pattern as in the case of the unbleached pulps. The strength losses due to bleaching seemed to bear no particular relation to the wood properties. The loss in bursting strength was low—ranging from 3 to 9%, while the losses in resistance to tear were about 30%, and those for the folding endurance ranged from 35 to 50%.

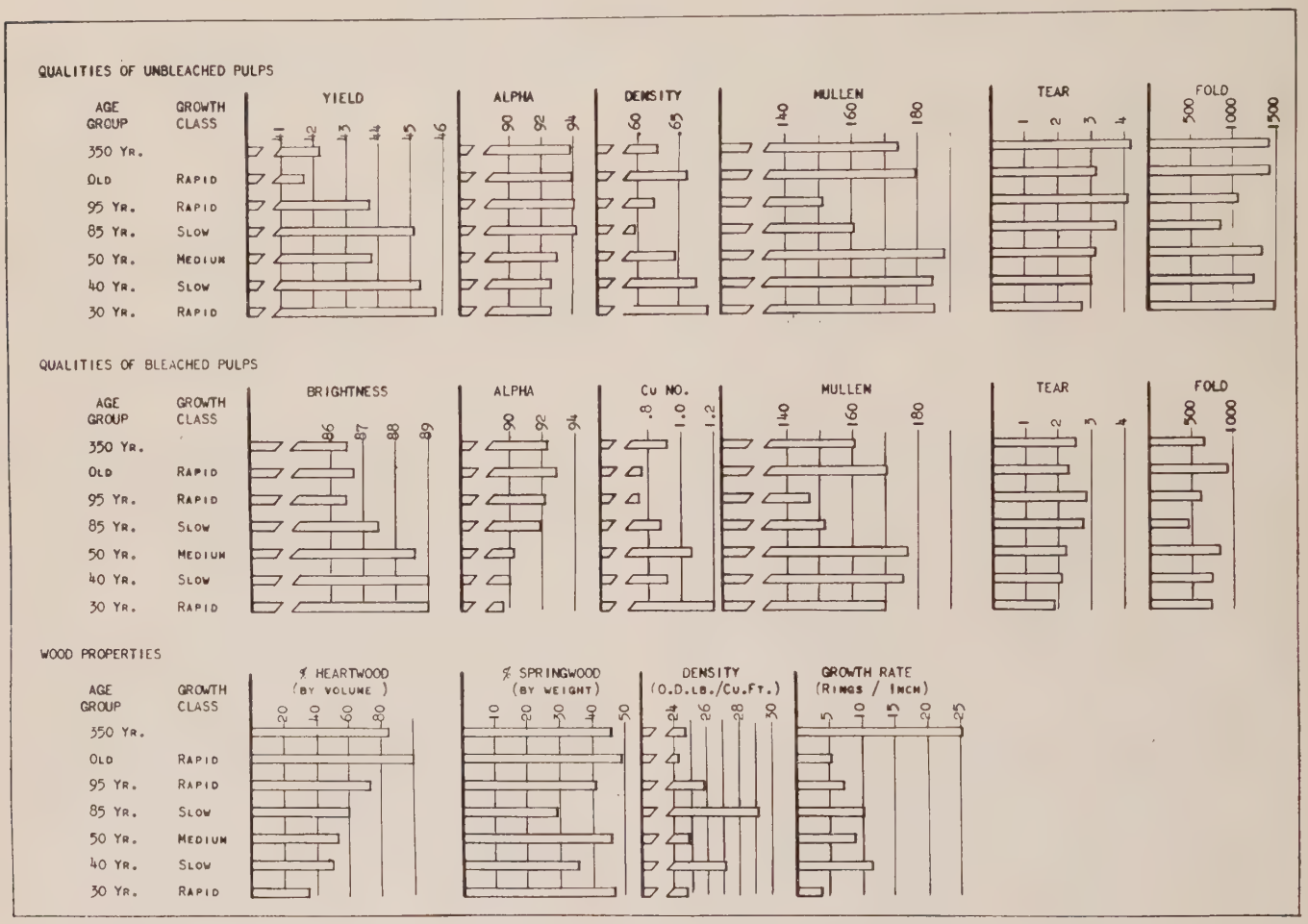

Fig. 4. Pulp qualities and wood properties

The young woods, particularly the very young woods, produced pulps which bleached to a higher brightness under the same bleaching conditions. This increase in brightness amounted to about 2 points.

Chemical Analyses

The per cent alpha-cellulose of the bleached pulps followed approximately the same trends as those of the unbleached pulps and ranged from 89.6 to 92.9%. That is, the old woods produced pulps of higher alphas. The loss in alpha in bleaching was greater in the case of the young woods, amounting to about 2.5% as compared to a loss of 1.0 to 2.0% for the older woods.

There was a slight indication from the higher copper numbers and also from the 10% KOH solubilities that the pulps from the younger woods suffered more in bleaching, under the same bleaching conditions, than did those from the older woods. In other words, the pulps from the younger woods required less drastic bleaching conditions for the same brightness.

CONCLUSION

In relation to Douglas fir wood properties, as shown in the samples of wood studied, the pulps from the younger wood generally showed higher yields, lower per cent alpha-cellulose, lower tearing strengths, and higher bursting strength and sheet density values. These age effects may be partially accounted for by the higher percentage of sapwood in the younger trees. The closest correlation with pulp strength properties was found with the percentage of springwood, being particularly close in the pulp folding endurance.

RECEIVED Sept. 26, 1949. Presented at the Fall Meeting of the Technical Association of the Pulp & Paper Industry, Hotel Multnomah, Portland, Ore., Sept. 11–15, 1949.

A Quality Control Factor for Insulation Board Pulp

H. Z. MOHRER, J. H. CONOVER, and O. W. FROST

A correlation between pulp quality factor values and the strength properties of insulation board makes possible the prediction of the type of board that will be made from the pulp tested. This offers the possibility of better control over the quality of production resulting in more efficient and less costly operation. By using radiant heat in the initial drying stage in addition to hot circulating air, a handsheet, 6 inches in diameter and weighing 14 to 17 grams is dried in 10 to 12 minutes. With this short drying period, a method of test is developed whereby the handsheet can be prepared, dried, and tested within 30 minutes. The burst test on the handsheet is found to give the best correlation between it and the strength properties of the finished board. In order to provide a basis for comparing the inherent strength values of various pulp types, it was found necessary to develop a mathematical relationship to indicate the strength characteristics of the pulp itself. An empirical formula is developed which results in a "Pulp Quality Factor" that is a measure of pulp quality.

THE NEED for standardized quality control methods has long been felt in the insulation board industry, but while manufacturing operations connected with insulation board are, in many respects, similar to those encountered in the production of paper, few efforts have been made thus far to develop control methods for insulation board which correspond to those widely utilized in the paper industry. The purpose of the investigation described here was the development of a positive, rapid test method for the determination of the essential strength properties of insulation board pulp which would be readily adaptable to mill conditions. Although many more factors influence the strength of insulation board than the ones on which the described method is based—drying operations, mat formation, and pressing, to name only a few—the establishment of a pulp testing procedure at a mill can be considered a major step in the direction of quality control of the finished board, and it may eventually become entirely possible to predict the various properties of the product considerably in advance of the final tests. Obviously, any method indicating probable mat strength fairly early in the manufacturing process makes it possible for the mill personnel to modify this property without an excessive waste of production time and materials.

The following characteristics are desired of a routine control test on insulation board pulp:

1. Results obtained from the test should be available to the operator no later than $^1/_2$ to $^3/_4$ of an hour after the pulp sample has been obtained.
2. The test should not require excessively complicated or delicate equipment.
3. The procedure should be of such a nature that a semiskilled laboratory worker can obtain accurate results after a short training period.
4. Results obtained from the test should readily correlate with transverse load tests obtained subsequently from the finished board.
5. Results should be duplicable within reasonable limits. Deviations of 5 to 6% from an average are permissible.
6. The conversion of actual testing results into a significant factor should involve a minimum of mathematical manipulations.

It should be noted here that the testing method described below was designed specifically for one mill producing insulation board; the range of pulp types covered was, necessarily, relatively small, tests having been confined to cottonwood and willow pulps prepared by grinders and Bauer disk refiners; a few of the pulps were prepared from steamed chips which were subsequently refined in a Bauer mill. These limitations also apply indirectly to the equipment used: much of this was specially designed and is not available commercially. It should be obvious, therefore, that the results obtained and quoted below are of rather restricted value and that entirely different evaluations might be obtained at mills using different pulp furnish and pulp preparation equipment.

EQUIPMENT

It will be noticed that the equipment required is in many respects similar to that used in paper-pulp testing. There were, however, some important modifications introduced which were necessitated by the special nature of the method and by the characteristics of the pulps which were to be analyzed.

Sheet Mold

A Valley sheet machine (8.5 by 8.5 inches) was used throughout all tests described here primarily because it was the only type available. In order to make the use of a highly diluted pulp-suspension possible the forming box of the mold was extended so that the water level could be raised to a point 14 inches above the wire. It is quite probable that the British Standard sheet machine specified by TAPPI Standard T 205 m would work entirely satisfactorily; this is especially true since it is desirable to use a handsheet of circular rather than rectangular shape. Three different screens are used with the sheet-machine; (1) 14-mesh screen fixed to the brass grid of the mold; (2) 150-mesh screen applied over the above; (3) 75-mesh removable screen which carries the formed sheet. Both (1) and (2) are fixed to the sheet mold. The use of the 150-mesh screen may not be necessary in many cases, but due to the extremely high freeness

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of the various pulps tested, it was introduced in order to reduce the drainage rate of the pulp suspension.

The handsheet obtained originally by this method was considered unsatisfactory for a number of reasons: the sheet was considerably larger than was necessary for the subsequent test; the rectangular shape produced corners which gave inconsistent testing results and made the drying of the sheet difficult; furthermore, it was found that various areas in the handsheet differed greatly with respect to weight and thickness. In order to eliminate these difficulties a steel cutter was designed which trimmed the sheet to the minimum area required and made it possible to select the most uniform section of the handsheet for testing. The cutter had a diameter of $6^1/_{16}$ inches, but it was found that shrinkage during the drying operation resulted consistently in a sheet exactly 6 inches in diameter. The moisture-free weight of this sheet was specified at 14 to 17 grams. The following factors entered into these standards of size and weight:

1. The handsheet had to be thick and heavy enough to yield consistent results. Since insulation board pulp is usually fairly coarse in texture and fiber dimensions, a relatively thick sheet, compared to paper samples, had to be used.

2. On the other hand, however, the sheet had to be thin and light enough to be dried in a very short period of time (an arbitrary limit of 10 to 12 minutes was proposed). It must be remembered in this connection that conventional insulation board of approximately 0.5-inch thickness usually requires a drying time varying from 1 to 2.5 hours. It is doubtful that this period could be reduced to much less than 45 minutes even under optimum conditions. In view of the $^1/_2$ hour allotted to the entire test, a sheet of $^1/_2$-inch thickness was, therefore, out of the question.

3. The handsheet had to be large enough to permit the tester to obtain an adequate number of testing values on each sheet. It was, of course, economically advantageous to restrict the sheet size to a minimum since equipment costs (especially of drying equipment) increase rapidly with increasing sample size.

Drying Equipment

By suitable pressing techniques (fully described in the procedure) the solids content of the handsheet can be raised to a maximum of 33 to 35% before the drying operation. At this point the sheet is structurally fairly firm and it remains for the drying procedure to evaporate the 65 to 67% water remaining in the sheet without damaging the latter's structure or degrading its cellulosic constituents. At the same time the drying period has to comply with the time limitations imposed by the test requirements.

A number of drying methods were considered and found unsuitable. Conventional photographic print driers, for example, have operating temperatures in the vicinity of 120 to 150°F., and the time required for the drying of a relatively heavy low-consistency sheet by this method is excessively high. Circulating ovens do not dry the sheet rapidly enough at moderate temperatures (up to 300°F.) and, above this point, tend to damage it after it has reached a moisture-free state. It must be considered that neither the weight nor the moisture content of the sheet can be rigidly controlled, and some allowance must, therefore, be made in the time element.

The use of radiant heat is also impractical unless some arrangement is made to carry off the water vapor as rapidly as it is formed and to remove the sheet at the exact end-point of the drying operation.

It appeared necessary, therefore, to use either a combination of radiant heaters with a circulating drier or, else, a circulating drier alone making use of a drying cycle. Both for reasons of convenience and mechanical efficiency, it was decided to develop a drying oven which incorporated a set of radiant heating elements. In conventional driers a large share of the total drying time is consumed while the temperature of the sheet-surface is raised to the boiling point of water. After this period, evaporation continues at a relatively high rate. The quickest method of drying a handsheet would, therefore, appear to comprise initial exposure to radiant heat for a short period followed by the evaporation of the remaining moisture by circulating air heated to 280 to 300°F.

The oven which was designed for this purpose makes use of these principles. Essentially it is a conventional forced-circulation type in which the air is thermostatically heated by a set of four cone radiators. In addition two radiant heating elements were incorporated which serve to supply the initial shock of radiant heat to which the handsheet is directly exposed during the first portion of the drying operation. The elements utilized are those conventionally used for hot-plates and are readily available at a very moderate cost. They are fixed to the walls of the oven in such a manner that the distance between the handsheet and each radiator is 6 inches. These heaters are operated entirely independently of the cone heaters and are controlled by an automatic timer which shuts them off after any desired period, usually 3 to 5 minutes. The remaining drying period is quite sufficient to evaporate all of the moisture from the sheet by means of circulating air alone. In this fashion it is possible to dry the handsheet safely and rapidly within the specified time limitations. Since, as is shown, the accurate weighing of the dry handsheet is of great importance in the determination of the pulp quality, a balance was mounted on the drier in order to permit the tester to obtain the exact moisture-free weight of the test sheet immediately at the end of the drying operation. In this manner it is also possible for the operator to obtain intermittent weighings of the sheet during the drying cycle and to develop drying curves for various samples, if desired.

Burst Tester

Although the burst test is of a rather ambiguous nature, depending, as it does, on a large number of factors present in the sheet (tensile and transverse strength, per cent elongation, etc.) it was found that of all test methods tried, it resulted in the best correlation with the transverse load test carried out on the finished board. A Perkins Mullen tester, equipped with a 60 p.s.i. gage, was used.

All of the remaining equipment was of the conventional types and is fully described herewith:

Equipment Specifications

1 Dipper (1000 ml.) (enameled or brass)
1 Balance (capacity approx. 1–500 gram)
1 Sheet forming machine: 8.5 by 8.5 inches: equipped with 14- and 150-mesh fixed screens
2 Pieces of 75-mesh wire-cloth, 9 by 9 inches
1 Stirrer for sheet machine, 8 by 8 inches
1 Timer or stop watch
1 Shallow pan to be used for acid washing wire cloths

100 Blotters, 9.5 by 9.5 inches, white, 0.02 inch thick, having an absorbency of 9–20 seconds when tested according to TAPPI standard T 423 m. This may be obtained from the Standard Paper Co., Richmond, Va. The commercial basis weight is 80 pounds (19 × 24—500)

1 Hydraulic press, capable of producing a pressure of 50 p.s.i. on the sample. Gage accurate to 1 pound

1 Drying oven, equipped with air-circulating system and radiant heating elements, the latter controlled by automatic timer. Also containing a device for weighing handsheets without removal from oven at the end of drying period. Balance to be accurate to 0.01 gram between 1 and 20 grams

1 Circular die, machined to $6^1/_2$ inches i. d. for trimming of handsheet

1 Mullen tester, equipped with gage reading 1 to 60 pounds

1 Brass roll, weighing 25 pounds having a face of 9.5 inches

1 Dial micrometer, capacity $^5/_{16}$ inch; spring pressure 7 to 14 p.s.i.

1 Rack for stacking blotters

1 Gallon can, enameled, for pulp sample

PULP TESTING PROCEDURE

Sampling

Fill the dipper with pulp obtained from a consistency regulated flow obtaining approximately 80 grams (moisture-free) of fiber. Fill the sheet-machine about one half full of water and add the pulp sample. Fill with water to the mark and agitate with stirrer until the sample has been well dispersed, then let all the water drain from the sheet. Open the sheet machine and place a piece of 75-mesh wire-cloth on the cake which should be $^3/_4$ to 1 inch thick. Place the brass roll on the center of the cloth and roll back and forth 8 times. Remove the cake from the machine and weigh out a portion from the center weighing 285 to 300 grams. This constitutes the pulp sample to be used in the formation of the test sheet.

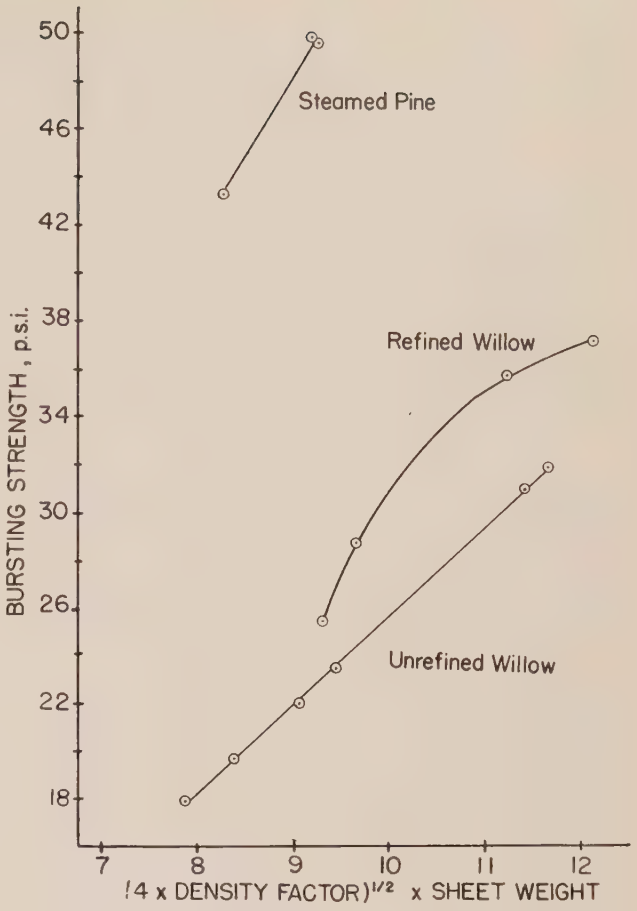

Fig. 1

Preparation of the Test Sheet

Insert a 75-mesh screen into the machine once more and fill the latter with water to a level just above the wire, so as to insure driving out all the air beneath the wire. Drop the pulp sample into the machine and fill it approximately one half full of water. Agitate rapidly with the stirrer until the pulp has been well dispersed and then fill the machine up to the mark with water.

Insert the perforated stirrer again and in 10 seconds move it steadily up and down 6 times. Repeat once more very slowly, and gently withdraw the stirrer.

Table I. Analysis of Three Different Pulp Types

1 Drainage, sec.	2 Weight, g./28.2 sq. in.	3 Thickness, m	4 Density factor, $\frac{\text{weight}}{\text{thickness}} \times 10$	5 Burst value, p.s.i.	S factor	Pulp quality factor	Pulp type
..	11.72	0.104	1128	17.95	153	228	Unrefined, mechanical
..	12.08	0.100	1208	19.76	164	236	Unrefined, mechanical
..	13.68	0.114	1198	23.52	172	249	Unrefined, mechanical
..	13.20	0.112	1178	22.03	167	243	Unrefined, mechanical
..	17.20	0.150	1146	32.03	186	276	Unrefined, mechanical
..	16.71	0.145	1152	31.04	186	274	Unrefined, mechanical
29.0	12.60	0.093	1356	25.48	202	274	Beaten, mechanical
29.0	13.10	0.097	1351	28.84	220	300	Beaten, mechanical
37.5	15.30	0.115	1330	35.89	234	320	Beaten, mechanical
37.0	16.10	0.115	1400	37.36	232	310	Beaten, mechanical
12.0	12.15	0.086	1414	49.87	410	545	Steamed, beaten, mechanical
12.0	12.30	0.088	1398	49.69	403	540	Steamed, beaten, mechanical
11.0	11.13	0.082	1360	43.33	394	534	Steamed, beaten, mechanical

Table II. Analysis of Five Pulps

Pulp No.	Sample No.	Weight, g./28.2 sq. in.	Density factor	Burst value, p.s.i.	S factor	Pulp quality factor	S factor, av.	Pulp quality-factor, av.	Modulus of rupture, 1/2-inch board
I	1	13.13	1218	20.01	152	218	158.0	230.0	320
	2	13.65	1218	21.69	159	228			
	3	13.40	1145	20.26	151	223			
	4	14.77	1152	25.05	170	251			
II	1	12.88	1170	20.25	157	230	161.0	239.8	336
	2	13.09	1110	20.15	154	232			
	3	13.50	1144	21.83	162	240			
	4	14.40	1109	24.66	171	257			
III	1	11.02	1173	18.90	171	250	171.8	248.8	354
	2	11.48	1220	19.36	169	245			
	3	11.90	1215	20.22	170	244			
	4	12.98	1190	22.90	177	256			
IV	1	12.80	1050	21.23	166	256	169.0	255.5	379
	2	13.79	1068	23.24	169	259			
	3	14.20	1128	24.09	170	253			
	4	14.52	1136	24.89	171	254			
V	1	11.60	1248	23.14	199	282	203.5	290.2	475
	2	11.75	1250	23.95	204	289			
	3	12.68	1230	26.56	209	299			
	4	12.51	1202	25.29	202	291			

After a pause of 5 seconds, during which time the surface of the liquid should have become almost motionless, fully open the drain-cock of the machine with a rapid movement, starting the timer at exactly the same moment. Observe the water draining from the sheet and stop the timer at the exact moment at which all of the free water has drained from the sheet. This point is easily observable by a change of color produced in the freshly formed sheet. Record the time elapsed as "Drainage Value."

Tilt the container, place the second wire cloth over the sheet, remove the two screens with the sheet carefully, and place the assembly on the press.

Pressing

Lower the top-platen until it touches the upper screen. Then raise the pressure to 50 p.s.i. in 20 seconds. Press for exactly 1 minute (stop-watch). After this, open the press and remove the sheet and wires. Remove the screens carefully and place the sheet on three dry blotters. Cover it with three blotters and again place the assembly in the press. Apply 50 p.s.i. for exactly 45 seconds. Then open the press and remove the sheet.

Trimming

Place the handsheet on a piece of hardboard and

Table III. Hourly Tests on Mill Produced Insulation Board Pulp

Day	Time	Pulp type	Drainage, sec.	S factor	Pulp quality factor	Modulus of rupture 1/2-inch board	Board density, lb./cu. ft.	Adjusted modulus of rupture 9–17 lb./cu. ft.
Mon.	9:30 a.m.	Mixture	15	178	267	...	...	...
	10:30 a.m.	Mixture	17	182	279	...	...	...
	11:30 a.m.	Mixture	15	179	268	273	16.5	290
	2:00 p.m.	Mixture	11	141	216	324	17.6	302
	3:00 p.m.	Mixture	15	138	206	291	17.3	281
	5:00 p.m.	Mixture	12	151	227	276	17.8	252
	10:00 a.m.	Bauer	10	214	310	...	...	...
	11:00 a.m.	Bauer	8	210	302	...	...	...
	12:00 a.m.	Bauer	10	226	330	...	...	...
	2:30 p.m.	Bauer	11	228	328	...	...	...
	3:00 p.m.	Stone	15	158	242	...	...	...
Tue.	10:00 a.m.	Bauer	8	160	239	...	...	...
	2:00 p.m.	Bauer	7	125	191	...	...	...
	10:30 p.m.	Mixture	14	182	270	293	16.7	304
Wed.	8:30 a.m.	Mixture	12	134	205	264	15.6	314
	9:30 a.m.	Mixture	12	163	252	269	16.8	275
	10:30 a.m.	Mixture	14	161	244	230	16.0	259
	11:30 a.m.	Mixture	11	145	223	240	17.3	232
	12:30 p.m.	Mixture	10	166	253	265	17.2	259
	1:30 p.m.	Mixture	11	156	239	...	...	...
	2:30 p.m.	Mixture	10	161	255	...	...	...
	4:30 p.m.	Mixture	12	180	273	258	15.8	299
	9:00 a.m.	Bauer	6	206	315	...	...	...
	10:30 a.m.	Bauer	6	226	351	...	...	...
	11:00 a.m.	Bauer	6	195	303	...	...	...
	12:00 a.m.	Bauer	8	212	327	...	...	...
	1:45 p.m.	Bauer	7	142	250	...	...	...
	3:00 p.m.	Bauer	8	195	307	...	...	...
	4:30 p.m.	Bauer	8	167	257	...	...	...

NOTE: The following formula was used to obtain the adjusted modulus of rupture:

$$\log (M.O.R._2) = \frac{\log 17.0 \times \log (M.O.R._1)}{\log (\text{Density})}$$

where

$M.O.R._2$ = adjusted modulus of rupture
$M.O.R.$ = actual modulus of rupture
Density = actual board density in pounds per cubic feet.

place the circular die over the center section of the sheet, choosing, if possible, a fairly uniform and flawless section. Place this device in the exact center of the handpress and raise the pressure rapidly to 100 p.s.i. Remove the device from the press and extract the sheet with *extreme care* from the circular die.

Drying

Attach the test sheet to the clip of the balance provided with the drying oven, and start the time cycle for the radiant heating elements. Check the oven temperature which should be 285 to 300°F. The radiant heaters should be cut off automatically at the end of 5 minutes. After a total drying time of 10 minutes, shut off the air-circulation system and record the weight of the sheet to 1/100 of a gram. Turn on the circulation system once again and remove the sheet from the oven.

Testing

Take ten thickness readings from the test-sheet, and then obtain ten tests on the Mullen tester. Add up the total thickness values and obtain the average value. Now add up the total burst values and obtain the average value. Using the test-values recorded (moisture-free weight, average thickness, and average bursting strength) obtain density and strength factors using the appropriate formulas.

During the 10-minute drying period, clean up all equipment, flood the fixed screens of the sheet machine, stack all wet blotters in the rack provided, and wash out both removable screens, using the acid bath if necessary.

MATHEMATICAL TREATMENT OF EXPERIMENTAL RESULTS

In order to provide a basis for comparing the inherent strength values of various pulp types, it was found necessary to develop a mathematical relationship which would indicate the strength characteristics of the pulp itself, rather than the over-all strength of the individual handsheet. To achieve this, considerable work was devoted to the correlation of bursting strength with the variables encountered in the preparation of handsheets. The most important of these variables were found to be the following: (1) the inherent strength of the pulp, (2) the weight of pulp used per handsheet, and (3) the density of the handsheet. This is based, of course, on the assumption that the technique of forming the sheets precluded any possibility of variations being introduced by differences in formation, clumps of fibers, inconsistent pressing procedures, etc.

The problem which remained, then, was that of determining to what extent the properties of weight and density affect the bursting strength of the handsheet, and to find the exact proportion of influence of these two factors.

The following empirical equations were found to give consistently reliable results:

1. In cases where little or no variation in sheet density was encountered:

$$S = \frac{M \times 100}{W}$$

2. In cases where considerable variations in sheet density were encountered:

$$P.Q.F. = \frac{S \times 100}{(4D)^{1/2}}$$

where

$P.Q.F.$	is the pulp quality factor expressed in empirical units
S	is the bursting strength factor expressed in empirical units
M	is the average bursting strength value in pounds per square inch
W	is the weight of the sheet 6-inches in diameter in grams
D	is the density factor obtained by dividing the sheet weight in grams by the thickness in inches and multiplying by 10.

Table I and Fig. 1 show results obtained when three different pulp types where analyzed according to the technique described above. These pulps can be superficially characterized as follows: (1) an unrefined, coarse, mechanical willow pulp, (2) pulp No. 1 but beater refined, and (3) a steamed, beater refined, southern yellow pine pulp.

From Fig. 1 it is obvious that excellent differentiation is made between the three pulps by the pulp testing method. (An interesting but as yet unexploited aspect of the plotted data would be the study of the curve-slopes which appear remarkably consistent for similar pulps.)

Table II shows a comparison between the pulp quality factors obtained from five different pulps and moduli of rupture calculated from tests carried out on $^1/_2$-inch, laboratory prepared boards of these pulps. Although all of the pulps fell roughly within the same range of values (all were of the same general type: unrefined, mechanical pulps) the differentiation demonstrated by the pulp test is remarkably consistent.

Table IV

Adjusted modulus of rupture, (to 17 lb./cu. ft.)	*S factor*	*Pulp quality factor*
232	145	223
252	151	227
259	161	244
259	166	253
275	163	252
281	138	206
290	179	273
299	180	273
302	141	216
304	182	270
314	134	205

Table III presents the record of hourly pulp quality tests obtained at a commercial insulation board mill. The moduli of rupture obtained from the finished board again show excellent agreement with the pulp quality factor. It is true that in some cases a lowering of the test factor is accompanied by what appears to be an increase in strength as demonstrated by the modulus. On closer inspection it will be found, however, that this increase is in all cases due to variations in density which do not enter into the calculations of the modulus. The pulp quality factor, of course, has been corrected

for density and, thus, does not show strength variations due to this variable.

Table IV shows a comparison between pulp quality factor, S factor, and modulus of rupture with the latter adjusted for a density value of 17.0 pounds per cubic feet which demonstrates the close relationship between these values in all but a few instances. Values are arranged in order of increasing adjusted modulus of rupture.

The importance of the drainage factor obtained during the formation of the handsheet has not been discussed thus far. Table III discloses substantial variations in the drainage time and it may well be that further research will show this part of the test to be of greater value than results obtained with conventional, divided-funnel types of freeness testers.

The method described in this paper for applying modified paper testing procedures to quality control work in insulation board mills has shown definite promise both in the plant and in the laboratory. It is hoped that this may be the first step in the direction of better production techniques and testing procedures for insulation board manufacture. At any rate, a tool has been developed which offers the producers of this commodity an opportunity to gain better insight into the properties of one of their raw materials and into the effects produced by subsequent stages of manufacture.

Received Aug. 24, 1948. Presented at the Annual Meeting of the Technical Association of the Pulp & Paper Industry, Hotel Commodore, New York, N. Y. Feb. 21-24, 1949.

The authors wish to express their appreciation to the U. S. Gypsum Co. which authorized the publication of this work and to the staff of the company's research laboratory which assisted them in the project.

White-Water Clarification

Savalla Vacuum Saveall Flotation Process

B. NIBERGER and R. E BODETTE

The method of operation of the Savalla saveall is described. The flotation principle in the unit is based on the theory of paper sizing developed by R. Lorenz (*1*) with the exception that air is infused in the white water. Various coagulants have proved satisfactory in the process. Those mostly used are aluminum sulphate, caustic soda, rosin size, animal glue, Turkish red oil, synthetic resins and "pitch," the latter being the final residue obtained in the manufacture of distilled red oil and tall oil. As a general rule when choosing coagulants for the unit no additional chemicals should be added to those already used within the mill system. A unit recently put into operation at the Deferiet mill of the St. Regis Paper Company is recovering approximately 8 tons of valuable solids a day, the average recovery efficiency being about 98%. Five different kinds of coagulants have been tried successfully. The recovered stock, which is of fairly light consistency, usually ranging from about 40 pounds per 1000 gallons up to around 100 pounds per 1000 gallons depending on the amount of solids contained in the white water, is put back direct to the fan pump on the paper machine without causing any trouble. Although this method has been followed in Europe for about three years, this is the first time it has been used in the United States. The high efficiency in recovering suspended solids from the white water and the possibility of selecting the most suitable coagulants result also in a high degree of B.O.D. reduction. Five-day B.O.D. tests by independent U. S. laboratories have shown reductions of well over 90%.

The savalla Saveall is, briefly, operated as follows: the prepared white water is conveyed by the white water pump to an admission chest, from which it is lifted by vacuum up through a vertical ascending flow pipe, to a horizontal flotation tank. In the ascending pipe the dissolved air is released and rising to the surface it carries with it the solids suspended in the white water. A fiber blanket is thus formed in the flotation tank and, assisted by the vacuum in this tank, it flows evenly and undisturbed by any mechanical device toward the front of the tank where it flows into a pocket and is sucked out and returned by a combination vacuum-stock pump to the machine system.

The clarified water collects in the lower part of the flotation tank and runs off by gravity through two vertical pipes, which together with the ascending pipe, support the flotation tank.

The pump which puts the recovered pulp back direct to the machine, or to some other part in the system, also maintains the vacuum of approximately 8 inches in the flotation tank. The pump is driven by a 3 hp. motor, these being the only moving parts of the unit.

COAGULANTS USED IN SYSTEM

The chemicals usually fed into the system are: aluminum sulphate, caustic soda, rosin size, animal glue, Turkish red oil, synthetic resins, and "pitch," the final residue obtained in the manufacture of distilled red oil and tall oil. The following have also been tried with success: sodium aluminate and calcium oxide. The chemicals are usually added to the system through rotameters at the white-water pump and at the injector before the water enters the admission chest. Because of the vacuum of about 8 inches working on the aerated water, comparatively small amounts of chemicals are needed to obtain proper flotation and recovery.

The flotation principle is based on the theory of paper sizing developed by R. Lorenz (*1*) with the exception of air injection in the incoming white water. When adding aluminum sulphate to the water the chemical reaction will give aluminum hydroxide. This

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hydroxide being loaded with positive electricity can be said to act as an "electrostatic cement" between the negatively loaded coagulant and the cellulose which also is negatively loaded when dispersed in water. Aluminum sulphate is generally present in paper mill white water. If not, a small amount has to be added into the system. If the pH is extremely low it is preferable to use sodium aluminate to obtain the proper amount of aluminum hydroxide and aluminum ions. It has been found that other sulphates, e.g., magnesium sulphate, sodium sulphate, and sulphuric acid which are very active coagulants, do not act with the same lasting efficiency when used for this purpose in place of aluminum salts.

Caustic soda is sometimes added by means of a separate dosage system. In very acid white waters, alkalies are added at times to obtain the aforementioned effect of aluminum hydroxide as an "electrostatic cement," in order to bring the pH back up to around the isoelectrical point. This is, however, rarely necessary, since the pH of most white waters is generally between 4 and 7.

Any other one of the aforementioned coagulants may be used to further contribute to the flocculation since the main task of these coagulants is to make the

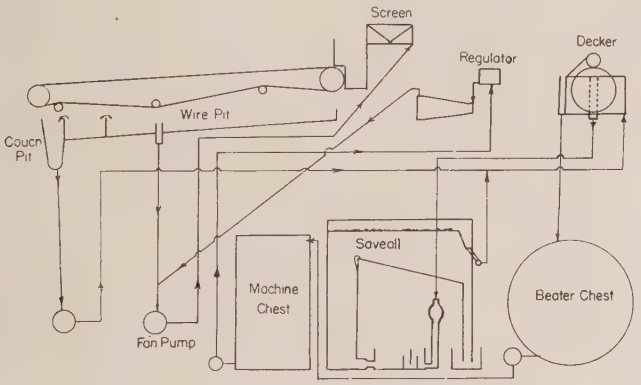

Fig. 1

solid particles in the water "sticky" to facilitate adherence of the small air bubbles created by the infusion of air.

Quite a few of the most common coagulants have been used with satisfactory results, however, the use of additional chemicals not already on hand in a paper mill should always be avoided. For instance, if a mill uses glue for retention or similar purposes, the same kind of coagulant should be fed to the saveall system.

The cost of the chemicals, including labor for preparation, is of course a major factor. The quantities of coagulants needed depend entirely on the composition and volume of the water to be treated and the type and amount of solids contained therein. Using aluminum sulphate (with about 17% Al_2O_3) and 70% solids, pale rosin size with 20 $\pm$2% of free rosin, the quantities usually are 50 to 200 pounds, and 30 to 60 pounds, respectively, per day.

OPERATING RESULTS AT THE ST. REGIS PAPER COMPANY DEFERIET, N. Y.

The saveall unit, capacity around 1000 gallons per minute, size about 20 feet long, 11 feet wide, and 14

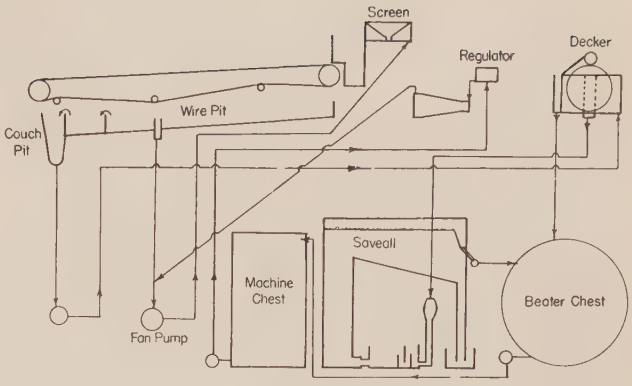

Fig. 2

feet high, was put into operation with the setup shown in Fig. 1. The main difficulty here was the decker because it did not have the capacity to handle both the machine's white water and the recovered stock from the saveall. It was necessary to bypass a large amount of rich white water and a lot of the fines contained therein were lost.

The next trial was the system shown in Fig. 2. In this trial the capacity of the decker for white water was increased but it was found that the reclaimed stock from the saveall was of such a light consistency that it was diluting the beater stock beyond the point of control.

Figure 3 indicates the next setup. This arrangement was successful only during periods of good machine operation. At times of breaks on the machine when the sheet dropped to the couch pit, the white-water consistency was raised to a point where the saveall was definitely overloaded. Most of the stock could be floated at times of breaks, but the fiber blanket formed in the vacuum tank became so heavy that it would not pass over the overflow dam. It was proved in this trial, that the unit would handle all of the normal white-water overflow and it was only the extremely heavy stock at times of breaks that could not be handled.

Figure 4 illustrates the next step taken. It appeared questionable to put the recovered stock directly back to the machine at the wire pit, but it seemed the only logical place for it. Since there was no variation in weight, freeness, formation, etc., this method was used for several days until it became apparent

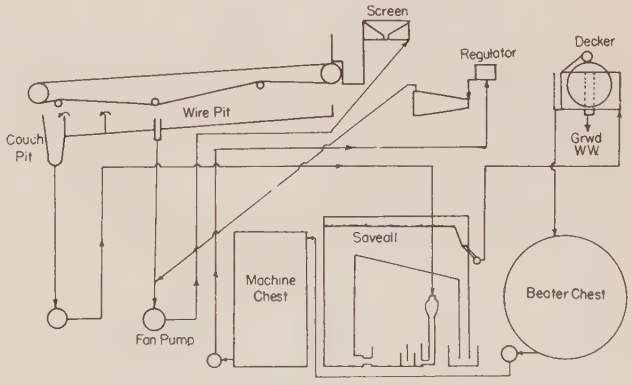

Fig. 3

that a certain percentage of the salvaged stock was bypassing the fan pump and was merely being recirculated in the system. To overcome this the method was changed to the one indicated in Fig. 5. Here all the recovered stock from the saveall was passed directly to the fan pump and thus all available fines were put back into the sheet.

During the trial period the groundwood content of the sheet was 60 to 70% and the consistency of the feed to the saveall varied from 31 to 8 pounds per 1000 gallons with an average of 20 pounds per 1000 gallons. The average consistency of the clarified water was about 0.004%. About 50% of the recovered solids was filler and about 65% of the solids in the tray water was fiber.

Rosin size and three different types of glue were used in these trials and all proved successful. No additional alum was needed, the amount used on the machine being sufficient. With a steady white-water volume of about 800,000 gallons per day treated in the unit, the quantity of glue needed was around 124 gallons per hour, of which 100 gallons were added in the headbox for retention and 24 gallons at the saveall. This proved to be a reduction of about 35% in coagulants needed to treat the same white-water volume by other methods used in the mill.

It was proved that the saveall unit is not overly sensitive to normal pH changes in the tray water. The mill operated under pH variations from 4 to 5 and no compensation was made. It was also found that the unit would handle normal variations in consistency and volume with the consistency of the recovered stock remaining almost constant.

Chemicals were admitted to the system at all possible points and little difference in the results were found.

There is only a 10-minute lag between the moment the tray water leaves the machine and the time the recovered stock returns to the machine. This short interval was beneficial because trouble such as dirt, slime, off-color, color changes, etc., could be handled very quickly.

The following figures were compiled by the laboratory from a 24-hour composite sampler and are representative of the grades produced on one machine.

The addition of a flocculating agent in the headbox, aids materially in the efficient operation of the saveall. The unit works best if the agent used is the same as

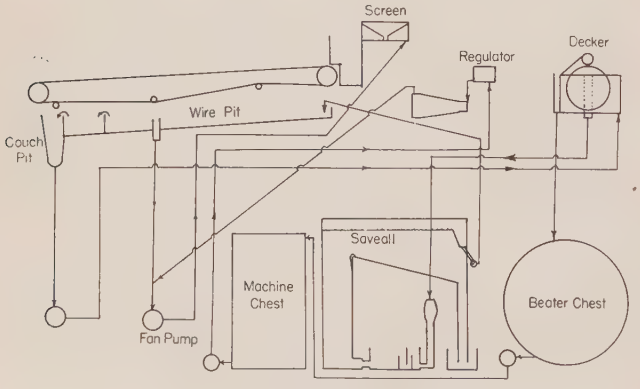

Fig. 4

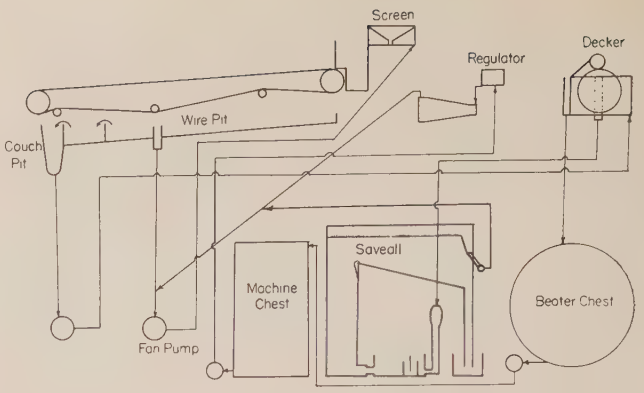

Fig. 5

is used on the machine for retention purposes. The unit is rated to handle stock at an average 12 pounds per 1000 gallons, but is operated over that level most of the time. The saveall is apparently an excellent recovery agent but when it was occasionally operated beyond its rated capacity a corresponding drop in efficiency was experienced.

The operation of the unit was found to be cheap and consistently efficient. The recovery of solids (fiber and filler) obtained under trial method 5 was nearly 8 tons per 24 hour day which was accomplished at an average operating efficiency of about 98% of an incoming white water containing an average of 20 pounds of solids per 1000 g.p.m. Since the recovered stock has a consistency of only $^1/_2$%, it was put back to the sheet directly without causing any machine trouble.

Date	*Machine speed, f.p.m.*	*Weight, lb.*	*Furnish groundwood-sulphite*	*Feed lb./M gal.*	*Effluent, lb./M gal.*	*Efficiency, %*	*Wire pit, lb./M gal.*
Jan. 28	650	25	65–35	12.4	None	100	
Feb. 19	650	25	70–30	9.9	0.33	97	19.5
Feb. 15	650	25	65–35	9.9	0.1	99	17.4
Jan. 31[a]	700	25	65–35	12.4	None	100	12.4
Feb. 7	715	30	65–35	11.7	1.6	85	24.9
Feb. 17	750	23	55–45	15.1	0.5	97	25.7
Dec. 11	800	30	70–30	18.2	0.8	96	25.6
Feb. 8	850	30	65–35	11.6	1.6	87	24.9
Jan. 17[b]	900	25	70–30	17.9	10.6	40.8	22.3
Feb. 5[b]	900	24	65–35	20.4	1.2	94	24.9
Feb. 4	920	24	65–35	18.4	0.5	98.9	26.5

[a] 1% titanium, 8% clay.
[b] These two orders were practically the same but the differences came from changing the setup and improving operating technique.

To date no sign of slime accumulation has been noticed, however, the unit is easily cleaned and no trouble should arise from this direction.

The unit requires a little more attention at the time of start-up than do other types of savealls in the plant, and while it may be difficult for some of the mill personnel to understand the theories and hydraulics of the unit in detail, uniformly successful operation by them is easily attained.

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Received Dec. 21, 1948. Presented at the Annual Meeting of the Technical Association of the Pulp & Paper Industry, Hotel Commodore, New York, N. Y. Feb. 21-25, 1949.

LOCAL SECTION ACTIVITIES

Reports of Meetings, Personnel and Events

Maine-New Hampshire

About 150 members and guests of the Maine-N. H. Section attended its Fall Meeting on October 21 and 22 at the Lafayette Hotel, Portland, Maine. The theme of the meeting was "Chemical Reinforcers as Applied to Papermaking" which was ably discussed by qualified speakers.

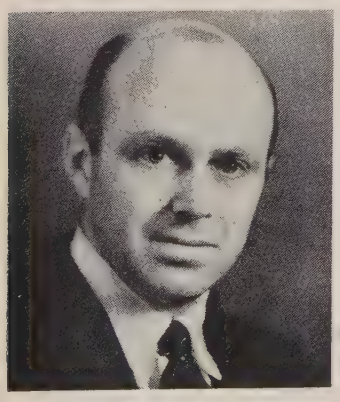
The first technical meeting, held on October 21, was introduced by Chairman John L. Parsons, Hollingsworth & Whitney Co., who presented Richard S. French, Keyes Fibre Co., who presided at the opening session.

W. H. Aiken, assistant manager, Chemical Division, Goodyear Tire and Rubber Co., presented the first paper entitled "Trend of Plastics in the Pulp and Paper Industry." A comprehensive review of the use of thermosetting and thermoplastic compounds in the pulp and paper industry was given by the speaker. He stated that the plastics industry has finally become of age, the key word of which is to "use plastics where plastics belong." The consumption of plastics in this country has increased sixfold from 1939–1948; over this same period there has been a 1.6 fold increase in the paper industry. In 1948 the tonnage of all plastics produced amounted to about 3% of the total paper and board production. Although this is a small percentage compared to the paper industry, when one considers the average price per pound for plastic material is about 30¢, it is seen that this young industry has made great strides. More recently there is the trend for the potential customer of a plastic material to define to the plastic manufacturer the properties he desires in his end product. This condition will promote more widespread use of plastic material through production of products better suited to an end use.

Mr. Aiken limited his discussion to those applications in which plastic materials are used in or on a paper sheet to impart functional or decorative properties. In those cases the identity of the paper is retained.

Thermosetting resins, typified by the phenolic, urea, melamine and polyester resins, are partially polymerized by the manufacturer and further polymerized in the plant of the user by the application of heat and/or pressure. Perhaps the most important use of these materials is for the production of wet strength papers.

Thermoplastic materials, on the other hand, are completely polymerized in the plant of the supplier and may be formed and reformed by the application of heat and pressure. These can be divided into four general classifications: cellulose derivatives, rubber derivatives, vinyl and substituted vinyls, and polyamides. The speaker briefly described each class of these materials. He stated that cyclized rubber and chlorinated rubber are the only derivatives of this type of interest for treating paper. The former has been most widely used in the industry as a water vaporproof, heat-sealing coating. Small amounts of cyclized rubber are added to wax coatings to raise the softening point and give greater resistance to abrasion.



John L. Parsons, Chairman, Maine-New Hampshire Section

The vinyl family of polymers has come into large production during the past 10 years and this growth has been in a measure responsible for the large growth of the plastics industry. The vinyl family not only includes polyvinyl chloride and copolymers but also polyethylene, polystyrene and copolymers, and polyacrylates and polyvinylidene chlorides.

Demand for polyethylene has always been ahead of supply until this year. This material promises to be used widespread in the packaging industry. It requires no plasticizer, has excellent low temperature characteristics, good aging characteristics, and is odorless, tasteless, and nontoxic. It has good resistance to the passage of water vapor but is not outstanding in grease resistance. Polyethylene has been used in the paper industry as a solution coating, as a hot melt, as an additive to wax hot melts, and by application to paper at the calender.

Mr. Aiken remarked that there are approximately 30 different vinyl chloride type resins available. These resins offer good water and grease resistance, and possess good toughness. They can be formulated to give a wide range of properties. In recent years vinyl chloride type latices have appeared on the market and are finding use in the manufacture of washable wall papers and greaseproof wrapping papers. A recent development is their use in nonaqueous dispersions. Some grades of resin can be dispersed in a plasticizer alone to give a workable viscosity. These mixtures are termed plastisols. For some grades of vinyl chloride type resins, it is necessary to dilute the plasticizer with a nonsolvent liquid for the resin to obtain workable viscosities. These mixtures are known as organosols.

According to the speaker polystyrene, when copolymerized with other materials such as butadiene, can be transformed into usable products. Some of these products are available as lacquers or can be modified with other resins and waxes to give desirable properties to paper. Latices and emulsions of both polystyrene and copolymers have been used as beater additives to increase the stiffness of paper. These latices appear to be equal to casein in bonding power and tend to minimize curl, give less flaking, better wet-rub resistance and less sensitivity to changes in humidity.

Polyvinyl alcohol gives an excellent grease resistant coating; the material is water soluble, however, and should be used only in applications where it will not come in contact with water. A latex of one of the vinylidene copolymers is available which gives films of good oil and grease resistance, good chemical resistance, and good heat seal.

The acrylate polymers impregnated into a sheet impart toughness and tear resistance. Their retention of color is good and they possess good aging properties; their application is limited by their high cost. Polyamides have not found extensive application in the paper industry up to the present time.

The "Use of Natural and Modified Starches in the Beater" was discussed by O. R. Steffens, Penick & Ford, Ltd., who presented this subject in the light of recent knowledge. Although the problem of starch structure has not been solved, in the past ten years great strides have been made. Unmodified corn starch, ordinarily known as pearl corn starch, is believed to consist of about 70% amylopectin and 30% amylose. Mr. Steffens agreed with others that starch

is not absorbed by the fiber but adheres to it by mechanical means. The addition of starch at the beater is more effective in heavier weight sheets than in lighter weight sheets. Mr. Steffens stated that the most significant change in the addition of starch to paper stock during the past 20 years is found in the fact that more cooked or swollen starch is being added to the stock after the beater and jordans and less starch is being added directly to the beater. This method of addition permits a more rapid control of sheet properties and reduces the tendency for starch particles to be broken up by the mechanical action of beaters and jordans. Although the grades and kinds of starch used today are about the same as 20 years ago, there is less oxidized starch used and the use of tapioca starch has declined due to high prices. Due to the price of starch, potato starch has found application in some sections. By far the largest use of starch in the beater is cooked or swollen pearl corn starch. Mr. Steffens reported that his experience in laboratory work and actual paper mill tests indicates that the use of pearl corn starch results in (1) increased mullen, (2) less surface fuzz and dust, (3) improved erasure, (4) harder sheets, increased rattle or improved field, (5) increased pick test, (6) increased tensile strength and (7) increased ash of clay-filled sheets. Although recent literature is not explicit in recommending the cooking temperatures for starch, Mr. Steffens said that his own laboratory work has indicated that 160° F. is not ordinarily sufficient. To be on the safe side the minimum temperature should be 180° F. and there is no loss in effectiveness when the starch is cooked to 212° F. For improved retention of clay, some mills add pearl starch to sufficient water to make about a 5–6% concentration, then add 1% of caustic soda based on the liquid weight. This mixture is heated with live steam to 140° F. and held at that temperature for 15 min. Then it is diluted with cold water to 2.5% concentration. This makes a light, easily-handled, very adhesive starch solution.

Experience has shown that some paper mills encountering rosin sizing difficulties, especially when their water supply is warm, are able to obtain adequate sizing by the use of an oxidized starch. Under these conditions the oxidized starch must first be cooked to at least 185° F. and the cooked starch must be added to the beater and well mixed before the addition of alum. This highly colloidal cooked oxidized starch seems to exert a protective colloid effect which keeps the rosin particles from collecting to form large aggregates with greatly reduced covering and size power. Rosin size and water conditions vary from mill to mill but a simple laboratory test using rosin, alum and a cooked oxidized starch may serve to demonstrate the protective colloid qualities of an oxidized starch. Compared to thick boiling starches, the use of oxidized starches results in a softer sheet, with less rattle.

Starch in the beater is not a catalyst; it cannot perform miracles. Starch is chemically and physically somewhat similar to cellulose; in its cooked form it acts like a highly hydrated cellulose. Assuming the addition of 3% of starch and retention in the sheet of 1% starch, we cannot expect this 1% to alter radically or make up for the shortcomings of the other 99% of papermaking material in the sheet. Mr. Steffens concluded with the statement that to determine the true facts about the value of a beater starch addition, the test should be conducted over a long enough period to average up the variables.

Francis H. Snyder, President, Snyder Chemical Corp., made a progress report on the "Manufacture of Plastics by the Beater Addition Process." The speaker opened his paper by defining the word "plastics" to cover a fairly broad range of resin-reinforced fiber products or fiber-filled resin products.

The criteria for good beater addition of phenol-formaldehyde resins are in part: (1) their use must not complicate the production of paper, (2) they must work in conventional paper mill equipment, (3) retention and yields must be high, (4) the products must perform basically as do the conventional materials, with special reference to storage, handling, aging properties and the characteristics of the end-use products, (5) freeness or drainage rate must not be impaired, (6) resin prices must be competitive, and (7) broke must be reclaimable and reuseable for the same grades.

Mr. Snyder stated that his Company's initial work in this field was to develop furnishes for the production of plastic pulp products, laminating papers, and other molding stocks containing 40–75% resin. For this purpose a single resin was developed and now four distinct classes of beater addition phenolic materials, all of which are liquids, are available. The addition of these resins to the beater is no more complicated than beater sizing with rosin. After the addition of the diluted resin emulsion to the beater and adequate mixing, the resin is precipitated by the use of papermaker's alum acidified with either sulphuric or phosphoric acid. The retention is claimed to be in excess of 90%. After the resin-coated fibers have been made into molding stocks, they are cured under the influence of heat and pressure and the resin film softens and flows with the fiber. The more cationic the fiber surface is before the resin addition, the more difficulty there is in removing the resin by extraction. No method of extraction has been found which will remove the resin after the plastic has been dried.

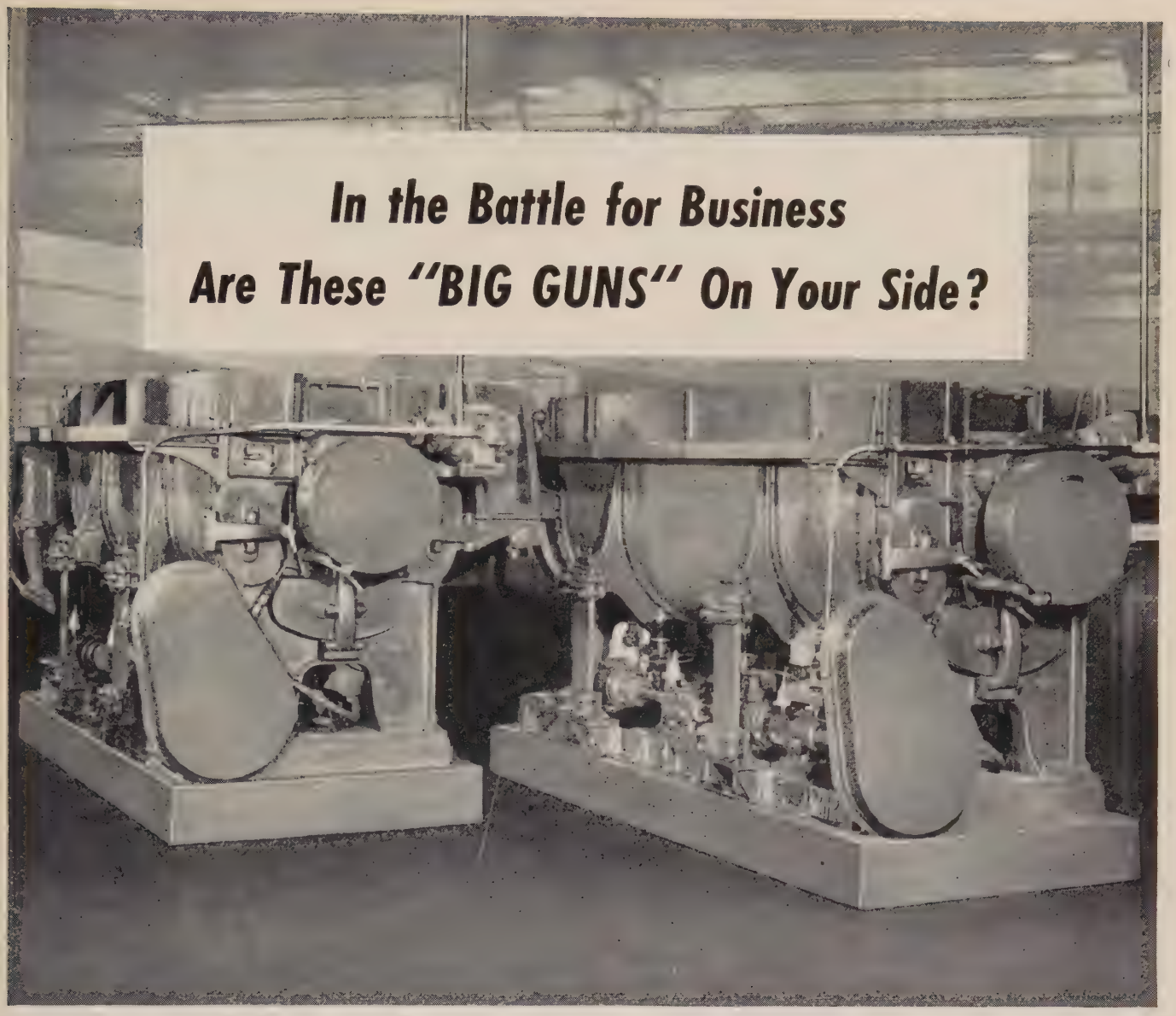
The formation of a natural sheet of paper is permanent but the resin-treated sheet undergoes reformation upon curing. It is partly due to this effect that such papers exhibit an enormous wet strength, dimensional stability, resistance to wetting, and inertness to chemical reagents. Resin-treated fibers, following a long soaking in water, do not swell appreciably. The magnitude of these effects is a function of resin concentration. Generally speaking, this means the addition of about 20–35% of resin based on the total furnish and it is in this range that most of these striking phenomena have been observed. In this range the wet strength of papers usually exceeds 100% based on the dry strength of the treated paper.

Mr. Snyder added that wet and dry broke are handled with ease so long as the final cure has not been affected. A cured paper cannot be defibered except by cooking at 100° steam pressure with caustic soda.

In the range of 3–5% these phenolic resins are used to improve the bond between synthetic rubbers and fibers. In this range the wet strength properties reach values of about 50%, sizing effects begin to show up strongly and the fibers begin to lose their affinity for water. With resin concentrations of 10 to 35% very high wet strength papers are possible. These find application as filters, honeycombs, high-pressure core stocks and other specialties.

Products made from papers containing 45–55% resin become highly plastic in nature and are used for low and intermediate pressure molding, laminating, etc. A development of unusual importance, according to Mr. Snyder, is the production of both general purpose and light-colored molding powders by the beater addition process. These compounds compare advantageously with general purpose phenolic powders of commerce. Beater addition resins having excellent electrical properties are now available and these are particularly good with respect to power factor and dielectric constant.

These new resins can produce a considerable variety of products. Mr. Snyder announced the development of a new resin, essentially phenolic in character, possessing a very light color and good stability to the action of light and heat. This material makes possible entirely new types of molding compounds and decorative laminates. The



DROP-OFFS ARE DONE AWAY WITH at the wet end of board machines when Bird Screens like these go on the job. With today's high speed operation drop-offs are too costly to tolerate. That's one reason why board mills all over the continent are putting in Bird Screens.

Big, modern Bird Screens are potent protection against loss of business due to lack of quality. With paper buyers casting critical eyes on the cleanness and uniformity of every sheet, this is no time to limp along with outworn or inadequate screening equipment.

Take a look at *your* Screens, now. If you have any doubt about their ability to do today's job efficiently and economically, get in touch with us at once.

BIRD MACHINE COMPANY, SOUTH WALPOLE, MASSACHUSETTS

90% OF ALL THE PAPER MACHINES IN NORTH AMERICA ARE EQUIPPED WITH BIRD SCREENS

speaker was of the opinion that the paper industry will become a major factor in the production of future plastics and that a significant portion of this new plastics production is going to be made by the beater process.

A very interesting and colorful exhibit of materials made from beater-treated resins was displayed by Mr. Snyder and his associates.

At an informal dinner held on the same day R. G. Macdonald, Secretary of TAPPI, described his experiences at the recent Fall Meeting of National TAPPI in Portland, Oregon. He also spoke briefly of the other national meetings scheduled within the next few months.

An announcement was made by the Chairman that arrangements are being made for the holding of a joint meeting of the New England Section and the Maine-N. H. Section at the Wentworth-by-the-Sea, Portsmouth, N. H. on June 23 and 24, 1950.

Prof. Lyle G. Jenness, Department of Chemical Engineering, University of Maine, called attention to the coming dedication of two new buildings, the Plant Science Building and the Engineering Building, on November 5 at Orono, Maine. He extended an invitation to attend a research meeting on the "Utilization of Wood" to be held on the preceding day, November 4, at Orono.

The second and final technical session was held Saturday morning, October 22, with John B. Calkin, Director, Department of Industrial Cooperation, University of Maine, presiding.

Prof. Edward F. Thode, Department of Chemical Engineering, University of Maine, discussed "Influence of Surface Properties of Fibers on Papermaking." The speaker reviewed the present knowledge of surface properties of cellulose fibers and interpreted some of the recent investigations with respect to fiber flocculation, paper formation, etc.

It should be pointed out, said Prof. Thode, that this field is still one in which knowledge is quite incomplete and therefore is a field in which there is dissension and difference of opinion in the interpretation of phenomena. Fibers in an ordinary paper stock behave like a colloidal suspension, due allowance being made for the dimensions of the fibers as contrasted with the dimensions of ordinary colloidal particles. In many cases fibers behave like so-called negative hydrophilic sols. Such sols are sensitive to the action of positive ions when added to their suspension. They will tolerate relatively large amounts of monovalent positive ions but are subject to a strong coagulating effect in the presence of divalent or trivalent positive ions.

Fibers in a paper stock are larger than the colloidal size, although some cellulosic fibers used in papermaking possess dimensions close to the colloid range. In various investigations it has been demonstrated that cellulose fibers do possess surface characteristics of a negative, hydrated colloid in that a negative charge does exist on the fibers in water suspension and a large amount of water is known to be absorbed on the fiber surfaces. Using this reasoning, recent investigators have tried to explain various phenomena involved in papermaking on the basis of a colloidal system.

Measurements at the University of Maine indicate that the amount of alum usually added to the beater does not entirely neutralize the negative charge on the fibers. On the other hand, when Sveen glue is added to the furnish after the alum the negative charge on the fibers is lowered practically to zero; this condition would seem to put the suspension into a state of incipient coagulation. Such a state may result in an extremely rapid actual coagulation with the change of external factors, such as mechanical agitation, temperature, etc.

The question of the total surface area of the fibers is also one of concern to the papermaker, according to Prof. Thode. The pulp refining operations increase the surface area of the fibers. This increase in surface area is likely responsible, to a large degree, for hydration, that is, the absorption of more water per unit weight by the pulp. Not too much attention, however, has been given to changes in the fiber surface area brought about by chemical means. Thus it is entirely possible to absorb on the fiber surfaces a quantity of other material which would have a significant effect on the properties of the resulting paper. The use of carboxymethyl cellulose presumably fits into this category.

Not only are flocculation and sheet formation affected by surface area and electric charge but filler retention and sizing are definitely colloidal phenomena.

Prof. Thode concluded his discussion with the following statement: "Until the day, therefore, that we obtain the vital fundamental information that is still lacking on the surface properties of fibers, the mill man may still be helped by colloid science in the solution of some of his practical problems by application of very simple rules of thumb. The most important may be summarized as follows: polyvalent cations or dehydrating agents each induce a state of incipient coagulation such that addition of small amounts of the other or a change in external factors will cause rapid flocculation of the furnish. It is hoped that application of this and other rules which may be readily derived from our present knowledge of colloidal phenomena may save some effort in the solution of furnishing problems."

The final paper on the program was presented by A. P. Schreiber, Industrial Sales Engineer, Tracerlab, Inc. The subject of his discussion was "Application of Radioactivity Techniques to Papermaking."

Mr. Schreiber discussed the industrial uses of radioisotopes from Oak Ridge. He stated that a number of practical uses have been devised which will be of considerable benefit and interest to papermakers. A continuously indicating, noncontacting, basis weight gage for use directly on the paper machine is now available. This Beta Gage is a unique instrument for measuring and recording weight per unit area or thickness of various materials directly on the production line. It uses beta radiation from Oak Ridge produced radioisotopes to achieve a high degree of accuracy and sensitivity and is unaffected by variations in chemical composition of the material being measured. These Beta Gages are available not only in a recording type but also in an indicating model and a laboratory model.

Other plant and research uses of radioisotopes were described which either have been actually used or are potentially available, including tank gaging instrumentation, a highly sensitive specific gravity gage, pollution flow studies and corrosion and erosion studies by the utilization of tracer techniques. Following Mr. Schreiber's paper there was a brief panel discussion on chemical reinforcers as applied to papermaking.

The Technical Program Committee consisted of George Day, Brown Co., Berlin, N. H.; Richard S. French, Keyes Fiber Co., Waterville, Maine; and John B. Calkin, Director of the Department of Industrial Cooperation, University of Maine.

The Local Arrangements Committee comprised Joseph J. Thomas, S. D. Warren Co., Westbrook, Maine; Harold E. Pratt, Pejepscot Paper Co., Brunswick, Maine; and Fred H. Frost, S. D. Warren Co., Westbrook, Maine.

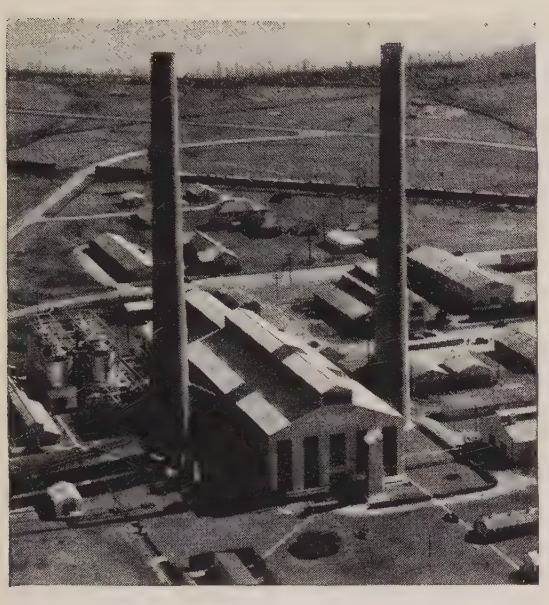
Ohio

The November meeting of the Ohio Section was held at the McCall Corp. plant in Dayton, Ohio on November 8, 1949, with 122 members and guests attending. After an excellent dinner served in the company cafeteria, the meeting was opened by Chairman Arthur Thurn of Champion

SULPHUR

*Interesting Facts Concerning This Basic Raw Material from the Gulf Coast Region

*MINING



The process of mining sulphur, as developed by Herman Frasch, takes advantage of the fairly low melting point of sulphur (about 240° Fahrenheit). The process resolves itself into three parts: one, operating a power plant that heats and pumps to the field large quantities of water; two, distributing the hot water through wells to melt the underground sulphur, and raising the melted sulphur to the surface; three, cooling and solidifying the sulphur in large vats from which it is broken and loaded into cars for shipment.

The power plant and water reservoir, as well as the vats and permanent structures, are placed at some distance from the sulphur deposit to avoid possibility of damage from surface subsidence, resulting from extraction of the underground sulphur.

Loading operations at one of the huge vats of Sulphur at our Newgulf, Texas mine. Such mountains of Sulphur are constantly being built at our mines, from which shipments are continually made.

TEXAS GULF SULPHUR CO. INC.

75 East 45th St. New York 17, N. Y.

Mines: Newgulf and Moss Bluff, Texas

Officers of the Ohio Section L to R: John L. Clouse, Corresponding Secretary, Don J. Goodman, Vice Chairman, Arthur Thurn, Chairman, R. C. McCarron, Treasurer, and Earl O. Knapp, Recording Secretary

Paper and Fibre Company. Harold Koch of Aetna Paper Company introduced Mr. Moon and Mr. Levy of McCall's. Mr. Moon gave a brief survey of the development of printing and the 4 and 5 color presses. Mr. Levy welcomed the group for McCalls and gave a brief description of the orgin of the McCall Corporation.

McCall's print 20 magazines for 17 publishers (1,000,000 copies a day). This requires 18,000,000 pounds of paper and 325,000 pounds of ink per month. There is a Postal substation at McCalls which handles 16,000,000 pieces of mail a month (more than the entire city of Dayton, Ohio). Mr. Levy gave an example of the scheduling that has to be done during the printing of a magazine. In the case of *Newsweek,* this magazine goes to press at 5:00 p.m. Monday and 30 hours later, 11:00 p.m. Tuesday, 1,000,000 copies have been printed and are in the mail. In such instances not only deadlines must be met, but emergencies must also be dealt with rapidly.

Mr. Levy also briefly described the operations in their pattern department producing 150,000 patterns daily.

After the remarks by Mr. Moon and Mr. Levy the group was escorted on a 2 hour trip through the McCall plant.

Harry F. Lewis, Research Associate and Dean of Students at the Institute of Paper Chemistry will talk on "Chemical Products of Pulp Manufacture" at the January 10 meeting at the Manchester Hotel, Middletown, Ohio.

New England

The New England Section met at Toto's in Smith's Ferry, Mass., on November 18, 1949. Phil. H. Bolton of the Robert Gair Co., presided as chairman. The guest speakers were Harry G. Specht, Vice-President and General Manager of the Eastwood-Nealley Corp., Belleville, N. J., and Peter S. Sinclair of the Sinclair Co., Holyoke, Mass. Both speakers gave interesting accounts of their recent visits to several European countries and conversations with men in the various paper mills.

Chicago

The Chicago Section met at the Chicago Bar Association Rooms, 29 N. La Salle St., Chicago, Ill., on November 21, 1949. George A. Zinkel of the Container Corporation of America presided as chairman.

The principal speaker was Burt Rike, Technical Executive of the Lakeshore Electrotype Co., Chicago, who talked on "Press Make-Ready of Printing Plates." In this talk he explained the Bishop-Stansell method of treating printing plates. This process lowers high lights, middle tones and type areas in order to improve quality, lower cost of make-ready, and increase the life of printing plates.

A sound film "Breaking the Bottleneck," was shown. This dealt with the use of pneumatic hammers for stripping.

Kalamazoo Valley

The Kalamazoo Valley Section met at the Columbia Hotel, Kalamazoo, Mich., on November 3, 1949. Stephen T. Kukolich of the Lee Paper Co., presided as chairman. Bruno E. Prevost, General Manager of the Emerson Manufacturing Div., John W. Bolton & Sons, Lawrence, Mass., talked on "The Jordan Plug Pressure Control System." This was followed by a panel discussion on stock preparation in which W. F. Hathaway, Kalamazoo Vegetable Parchment Co., F. C. Goodwill, St. Regis Paper Co., and J. J. Harrison, Michigan Carton Co., participated.

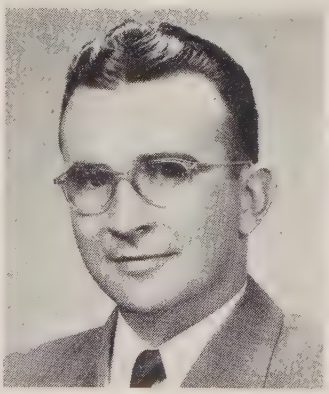
Lake States

The Lake States Section held its first meeting of the season at the American Legion Club House, Appleton, Wis., on October 11, 1949. George R. Sears of the Institute of Paper Chemistry presided as chairman; 114 members and guests were present.

The principal speaker was Otto Kress, Technical Director Emeritus of the Institute of Paper Chemistry who talked on "Dyestuffs in the Paper Industry." In his talk he sketched the historical background of the dyestuff industry and its development in the United States during and after World War I. He stated that although German products were superior until 1918 the industry has since made rapid progress and make dyes today that have no superior.

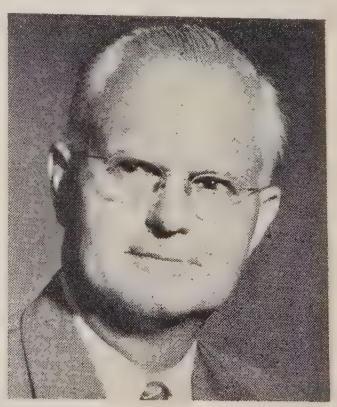
He then discussed the various troubles that vex the color-matcher in the paper mill. These include two-sidedness, mottling, effects of sizing and hydration and adjustments to beater furnish to obtain proper shades.

Arthur Thurn, Chairman, Ohio Section



George A. Zinkil, Chairman, Chicago Section

Stephen I. Kukolich, Chairman, Kalamazoo Valley Section



George R. Sears, Chairman, Lake States Section

PEDIGREED DOGS

THE POINTER:—Said to have come from Spain, is very highly prized for hunting, is a tireless worker in the field.

The DRAPER Felt

The Felt with a Pedigree

DRAPER BROTHERS COMPANY

Woolen Manufacturers Since 1856

CANTON, MASSACHUSETTS

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On November 3 the section visited the Wisconsin River Valley and made a tour of the Mosinee Paper Mills at Mosinee, Wis., and the new research laboratory of the Marathon Corp., at Rothschild, Wis.

Following dinner at the Wausau Club in Wausau, Wis., T. A. Pascoe of the Nekoosa-Edwards, Wis., gave a summary of the "Stream Pollution Problem from the Point of View of the Kraft Mill Operator," and J. R. Salvesen of the Marathon Corp., discussed "The Utilization of Sulphite Waste Liquor."

On December 13 at the American Legion Club House in Appleton, Wis., R. A. Diehm, Technical Director of the Ward Paper Co., Merrill, Wis., talked on "The Elimination of the Human Element in Determining Printing Quality."

Delaware Valley

The Delaware Valley Section met at the Engineers Club, Philadelphia, Pa., on October 27, 1949. August S. Erspamer of the P. H. Glatfelter Co., Spring Grove, Pa., Vice-Chairman of the Section, presided.

The principal speaker was George Welp of the Interchemical Corp., New York, N. Y., who talked on "Putting Rainbows on Paper." Mr. Welp's remarks in part follow:

"In using colored inks on paper it is necessary to have accurate means of measuring color and to know what the behavior of a color will be when mixed or combined with other colors. The spectrophotometer will accurately measure colors and give a three dimensional picture of any given color in terms of dominant wave length brightness and purity. The Munsell System will give a readily understood and definite specification of any given color in terms of hue, value, and chroma. This is much better than guesswork or a vague description of a "shade slightly brighter than this clipping from my wife's dress." It gives numerical values to such descriptions as "dirtier," "purer," "lighter," "more brilliant," or "grayer." Combinations of colors will give various impressions to the viewer. Adjacent colors on a Munsell hue circuit will produce pleasant, harmonious combinations, whereas, contrasting colors will produce striking combinations. If relationships are not anticipated their use will be an obstacle instead of a help.

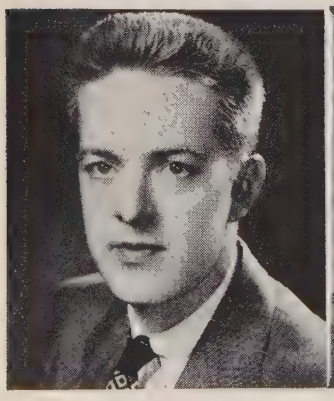
"The eye mechanism compensates for any overstimulation in order to keep colors in balance. One of the most striking is the same shade of green viewed against different backgrounds. The appearance is different, against yellow it becomes bluer and against blue becomes yellower. Two colors not the same can be made to look alike against different backgrounds. This phenomena can be made to work for us rather than against us in putting the 'Rainbow on Paper.'

"Color is only part of the job. The rainbow has to work on packages, on magazine covers, and on outside posters. If no light permanence is required the matter of selection becomes simpler. The number of choices possible are reduced by each different specified requirement. For example, only a few colors may be used in contact with caustic soda.

"Viewing conditions and light sources change the colors' appearance. Paper stock differences affect the color of the printed material. There are other problems beside color. For example, inks for newspapers are specified to be suitable for deinking."

In the discussion period following Mr. Welp's talk it was brought out that finish affects the color of the printed sheet. A rougher finish will look duller because it reflects the incident beam of light differently. Rub resistance of all colors is relative and may be absolutely overcome only by overcoating. Some colors rub off easier than others, particularly, dark blue. The inkmaker is usually cooperative in helping to solve pick problems. The tack of an ink can be adjusted within limits but poor printing will result if reduced too heavily. The customer requirements, the paper characteristics, the sheet size, the speed of printing, and the nature of the printing to be done are all factors affected or being affected by the wax pick characteristics of the paper. Mr. Welp stated that the paper at the press cannot be sent back to the mill, but was corrected by a chorus stating emphatically, "The Hell It Can't!" This was followed by hearty laughter by all present.

On November 30 the speaker at the Philadelphia meeting was Simon Collier of the Johns-Manville Corp., New York, N. Y., who talked on "Modern Quality Control."



John P. Weidner, Chairman, Delaware Valley Section

Walter F. Holzer, Chairman, Pacific Section

Empire State

Metropolitan Group

The Metropolitan Group of the Empire State Section met at Fraunces Tavern, New York City on Monday, November 14, 1949. John B. Calkin presided as chairman. The principal speaker was John Cornell, Co-publisher of Paper Mill News who talked on "Trends in the Pulp and Paper Industry." In this talk Mr. Cornell reviewed his prophesies concerning business in 1949 as made at the beginning of the year. Like Drew Pearson, John proved that he was 82.6% accurate. This is par for the course.

Western New York Group

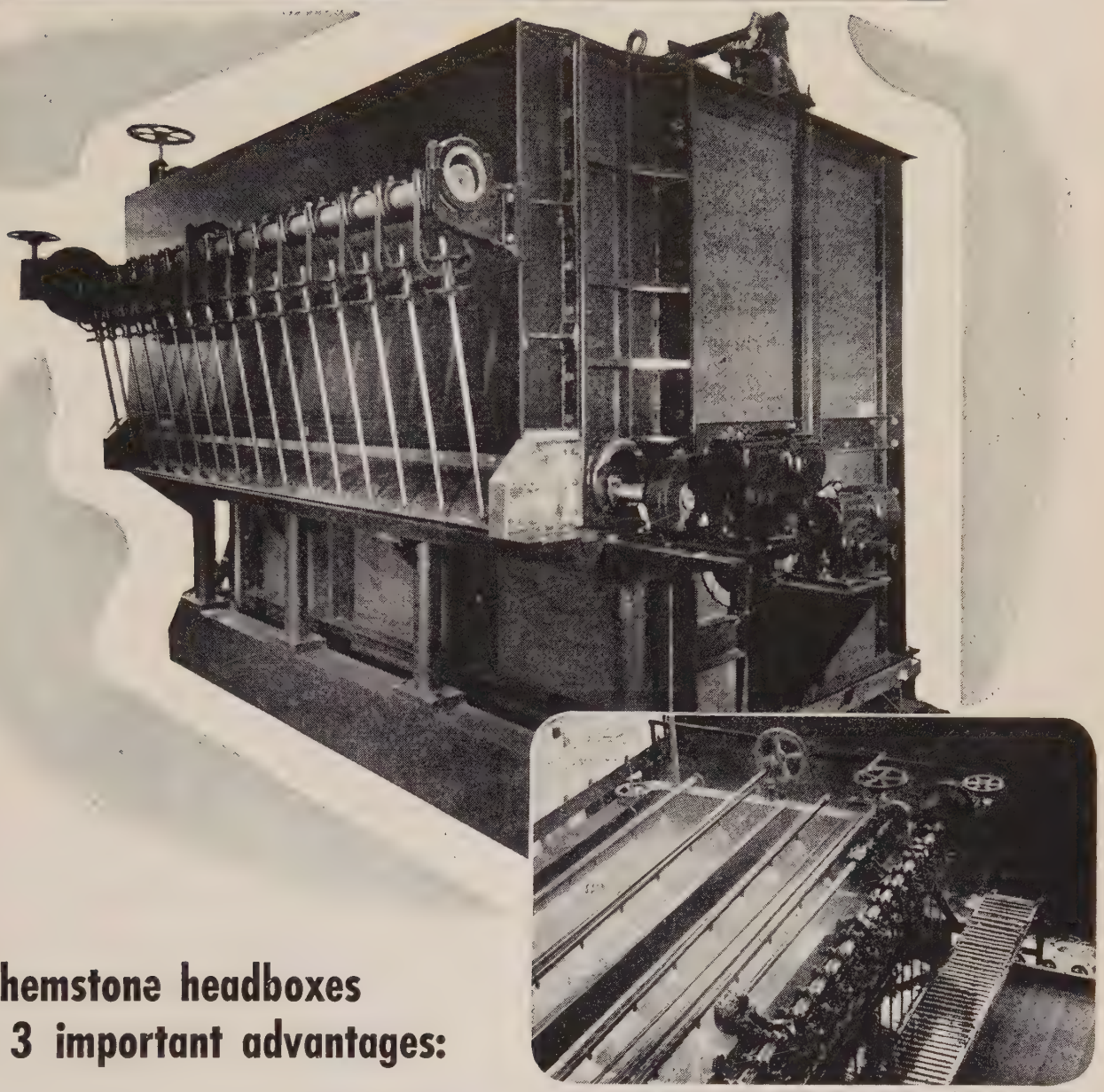
The Western New York Group met at the Prospect House, Niagara Falls, N. Y., on November 9, 1949. George Rand of the International Paper Co., presided as chairman. Two hundred members and guests heard J. P. Burke, President of the International Brotherhood of Pulp and Sulphite Workers talk on "Trade Unions in America." He traced the growth of unionism, paralleling its rise with industrial expansion. He also stressed the democratic principle of self-determination as the basic precept of the Constitution being an extension into union recognition by management. He further stated that peace between labor and management is necessary for continued welfare of each.

Hudson Valley Group

The Hudson Valley Group met at the Village Inn, S. Glens Falls, N. Y., on October 20, 1949. C. E. Hager of the Diamond Match Co. presided as Chairman. The speaker was S. A. Tomkins, Field Engineer, Johns-Manville Corp., who talked on "Transite Pipe."

First was shown an excellent picture entitled, "Underground Arteries" which is the story of Transite pipe and its use as transmissions and distribution lines in civic water systems. It showed the manufacture of the pipe from asbestos, portland cement, and silica. It showed the test-

Dimensionally stable...Clean...Chemically resistant



...Chemstone headboxes have 3 important advantages:

MADE of asbestos and cement, and integrally waterproofed, Chemstone is helping paper mill men solve the problem of headboxes, consistency regulator boxes, flow boxes, linings for wire and couch pits, and stock chests because:

1. It won't shrink or swell—Chemstone is a tough, monolithic material molded under high pressure. It has unusual dimensional stability due to its low water absorption factor. When used for headboxes and other purposes in mills, it is light but strong, provides an attractively finished job that lasts indefinitely.

2. It resists slime and bacteria—Chemstone boxes prove unusually resistant to bacteria and other surface accumulations. Chemstone stays clean for long periods, but when cleaning is necessary, it can be washed easily and quickly by a simple hosing operation.

Chemstone headbox *on Fourdrinier machine making Kraft wrapping from northern Kraft pulp.*

3. It resists chemical action—Chemstone possesses the ability of asbestos and cement products to resist chemical action. Equipment made of Chemstone is free from metallic oxides, resists both mild alkalis and acids, and is unaffected by most mill waters. For full details, write, for data sheet DS series 405, to Johns-Manville, Box 290, New York 16, N. Y.

JOHNS-MANVILLE JM PRODUCT

Johns-Manville PRODUCTS FOR THE PAPER INDUSTRY

ing of the pipe in which one test was a hydraulic pressure test at 4 times rated capacity. It explained the value of Transite pipe; (1) in quick easy installations; (2) in structural strength; (3) in tight joints; (4) in maintenance of flow capacity; (5) in long life; (6) in protection of water quality.

Mr. Tompkins spoke on the use of Transite pipe above ground. His talk consisted chiefly of the couplings, fittings and bracing of Transite pipe. Hydrostatic pressure within pipes above ground will tend to separate sections; therefore, rigid flanges and bracing must be used. Five flanges suggested for use with Transite pipe were discussed. Two of the flanges—the Simplex, and Ring and Follower—when used on exposed piping need bracing. Three other flanges—Tee-Tite, Poured Flange, and Screwed Flange—give rigid connections. Any fitting with proper flange may be used with Transite pipe. An example of suggested fitting is the Streed fitting. It is fabricated from steel and lined with Transite cemented with a chlorinated rubber compound. Bracing used should take thrust in line of resultant of forces to prevent bending moment in pipe. Slides on vertical and horizontal bracing were shown, after which the following discussion took place.

Question: What are the limits of pH condition under which Transite pipe is satisfactory?
Answer: Transite pipe may be used within a pH range from 4.5 to 14.
Question: What are some of the weights of this pipe in pounds?
Answer: The weight varies with class and size. To give examples: in Class 100, 6 inch weighs 7.8 lb./ft; 8 inch weighs 12 lb./ft; 10 inch weighs 20 lb./ft; 12 inch weighs 28 lb./ft; 14 inch weighs 37 lb./ft. For comparison, Class 150, 6 inch weighs 11 lb./ft.; containing considerable more material in wall thickness.
Question: To return to pH conditions, it was said under some conditions the pipe is good at a pH of 3.5—in other conditions it fails. What kind of materials cause the failure?
Answer: This is rather difficult to answer. Where good service is obtained with low pH solutions, it is probably due to the presence of buffers which protect the pipe from relatively strong acid conditions.
Question: Is there any limit in the other range—above 7.0 pH?
Answer: We have shown satisfactory performance on white liquor which has a pH of 14.
Question: Why was 13 ft. adopted as standard length?
Answer: Transite pipe originated in Italy about 1910 or 1911. It was licensed into this country. They were manufacturing to a metric system measure in lengths of approximately 13 ft. We have continued to do so.
Question: Has Transite pipe been used in stock lines?
Answer: Transite pipe is satisfactory for all types of washed stocks.
Question: Any adverse effect from peroxide?
Answer: You are probably referring to peroxide bleaching of groundwood. Transite pipe has been successfully used in this system. In fact, its freedom from metallic oxides which catalyzes the peroxygens, definitely recommends its use.
Question: Is water absorbency any problem?
Answer: Water absorbency is only a problem to the extent that if perfectly dry pipe were installed, a permanent linear expansion in a 13 ft. length would be approximately $^1/_8$ inch. Recognition of this permanent expansion must be taken into consideration when erecting pipe. We also might add that the thermal expansion of Transite pipe is comparable to that of concrete and is approximately 0.0000056 inches per inch of length per degree F temperature difference.
Question: How does friction compare to that of steel?
Answer: Very little is known regarding the friction of paper stocks in pipes. This subject is now being very carefully investigated by the Engineering Research Committee of TAPPI, and we hope to have some real data in the near future. Field experience would indicate that the coefficient of friction of Transite pipe carrying stocks, is approximately 50% of that when the same stocks are carried in metal pipes.
Question: To what kind of metallic pipe is Transite compared for this friction?
Answer: As indicated above, actual data regarding flow of stocks in pipes is very limited. The basis for the statement made above was a comparative test run between copper and Transite pipe under definitely comparable conditions of operation.
Question: Where has pipe proved unsatisfactory?
Answer: Transite pipe has not proved satisfactory on conditions of low pH such as lines carrying chlorinated stocks as are encountered in the first stage of direct chlorination of bleach systems. In our opinion, it is not particularly satisfactory for condensate lines, although some of the mills are using it for this purpose. In handling milk of lime, the lime has a tendency to build up on the inside of the pipe and presents some problem. However, we believe that by running green liquor through this line periodically that this difficulty could be overcome.
Question: Has it not been found that slime does collect in Transite pipe?
Answer: We do not make the statement that Transite pipe is totally slime free. Transite will collect less slime than the metallic pipes, but the slime that has been found to collect in Transite is a soft, gelatinous slime which has very poor adhesive qualities so far as its adhesion to the pipe is concerned.
Question: Has Transite been used as roll materials?
Answer: No. Its modulus of elasticity is about 4 million.
Question: Transite pipe will separate in laminae in various acids.
Answer: Transite pipe is not recommended for acid handling. We do know that acids will attack Transite and cause it to defoliate and expand.
Question: What are the temperature limits of Transite pipe?
Answer: The temperature limit of Transite pipe is largely controlled by the type of coupling used. With a threaded flanged coupling we can say that we have safely handled temperatures up to and including 212° F. With the poured type of coupling we know we can operate at a 150° F. temperature with a considerable factor of safety.

On November 17, William A. Stanier of Du Pont talked on "Power Problems of the Pulp and Paper Industry."

Northern New York Group

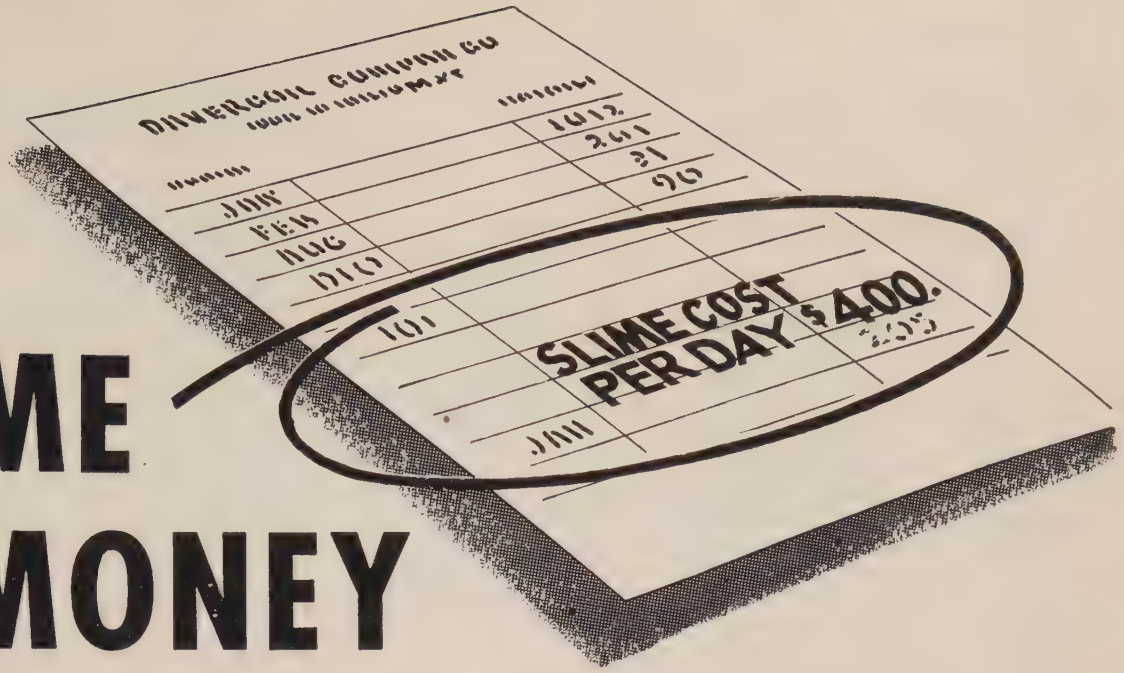
The Northern New York group of the Empire State Section met on November 10 at the Woodruff Hotel, Watertown, N. Y. Seventy-six attended the dinner preceding the meeting at which J. H. Heuer, Technical Director of St. Regis Paper Co., presided.

Mr. Heuer introduced the speaker, William C. Nusbaum, the New York Sales Manager of Tracerlab, Inc., who discussed briefly the chemical and physical behavior of radioactive isotopes and then described the instruments in which these isotopes were used for industrial applications, and for laboratory evaluations.

During the discussion following the presentation of the paper the following questions were asked:

Question: Can you measure quantitatively the radioactivity of tracer compounds, and then use this characteristic in measuring various properties in a coated sheet?
Answer: They use a Geiger counter in measuring the radioactive intensity in following the path of tracers in biological and medical studies. These instruments require a great deal more calibration, and as yet have not been adapted to fit the requirements of industrial applications except for a few cases that are under investigation now. The half-life and characteristics of the original isotopes also enter into the problem.
Question: It seems to me that they might have a practical application in the measurement of consistencies of pulp and water mixtures.
Answer: Some experiments have been run off along this line. The type of gage required has a greater measuring problem and is something that has not yet been accomplished.
Question: Could tracers be used in measuring distribution of starch-clay mixtures in coatings or is there some way one could measure the amount of coating being put on a sheet?
Answer: Some work has been done using the absorption type isotope instruments in measuring the weight of the sheet before the addition of the coating and then the weight of the sheet after the application of the coating, and using the differential as the coating weight being applied.

Dr. Davis, the President of Clarkson College of Technology, Potsdam, N. Y., was the speaker at the December 8 meeting. On January 12, J. P. Strasser, Manager of the Paper and Adhesives Dept. of Stein-Hall Co., will talk about the chemistry of starches and their application in the paper industry.



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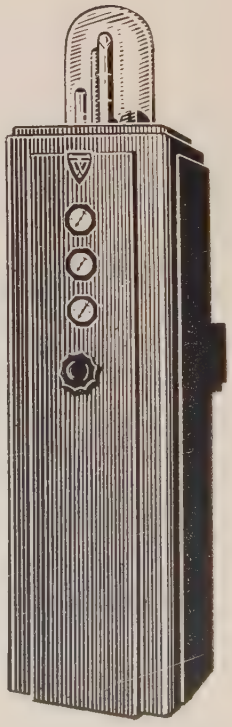

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I-28

Specification for Chemical Composition of Water for Manufacture of Soda and Sulphate Pulps*

TAPPI Tentative Standard E 603 s-49

THIS SPECIFICATION should be considered only as a guide in determining the quality of water to be used in the production of alkaline pulps.

DEFINITION

By alkaline pulps are meant those pulps produced by chemical cooking processes known as the soda process and the sulphate or kraft process.

LIMITATION

This specification for process water applies to pulp manufacture only and not to the subsequent manufacture of papers from alkaline pulps. It is prepared upon the premise that the pulp will be processed in the normal way and without a final treatment to offset the effects of undesirable impurities in the water. Process water of less purity is suitable if the pulp undergoes a final corrective treatment.

This specification is prepared upon the further premise that the pulps may be bleached.

CHEMICAL COMPOSITION

The water shall not contain impurities in excess of the amounts given below, expressed in parts per million and in terms of the substances indicated.

NOTES

1. Chlorides are limited to 75 p.p.m. because chloride concentrations in excess of this amount tend to promote corrosion of metal parts in the manufacturing system.

2. Calcium and magnesium compounds are limited to 50 p.p.m. each because of their tendency to form scales upon equipment and precipitates on the pulp where water comes in contact with the highly alkaline chemicals used in process.

3. Color, iron, and manganese are kept low because of their tendency to be adsorbed by and to lessen the brightness of bleached pulp.

4. Silica is kept low because of its tendency to be adsorbed by and to increase the ash content of the pulp, and its possible tendency to aggravate scaling in the evaporators and to interfere with the settling of the white liquor.

Substance	*Maximum, p.p.m.*
Turbidity as SiO_2[a]	25
Color in platinum units	5
Total hardness as $CaCO_3$	100
Calcium hardness as $CaCO_3$	50
Magnesium hardness as $CaCO_3$	50
Alkalinity to methyl orange as $CaCO_3$	75
Iron as Fe	0.1
Manganese as Mn	0.05
Silica (soluble) as SiO_2	20
Total dissolved solids	250
Free carbon dioxide as CO_2	10
Chlorides as Cl	75

[a] Materials causing turbidity shall not be gritty.

REFERENCE

TAPPI Special Report No. 375 "Process Water Used in the Manufacture of Alkaline Pulps (Both Sulphate and Soda Pulps)," prepared by the TAPPI Water Committee and issued January 31, 1948, as a confidential report by the Technical Association of the Pulp and Paper Industry.

* This specification has been approved as a tentative standard by the Water Committee. Criticisms are earnestly requested and should be sent to R. G. Macdonald, Secretary, Technical Association of the Pulp & Paper Industry, 122 E. 42nd St., New York 17, N. Y.

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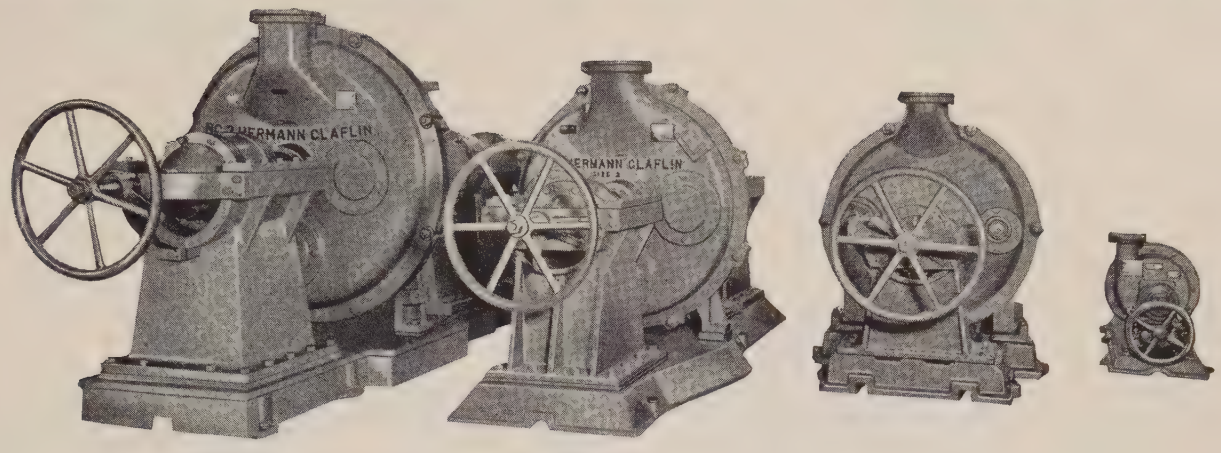

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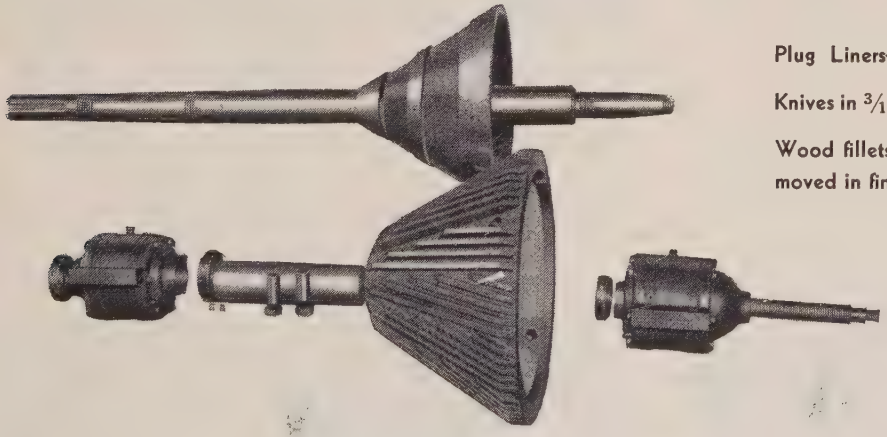

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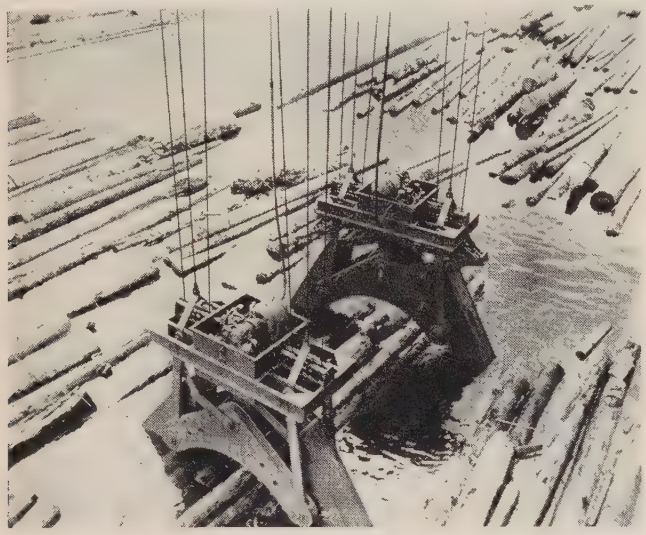
LANCASTER, OHIO

New Wood Mill at Camas

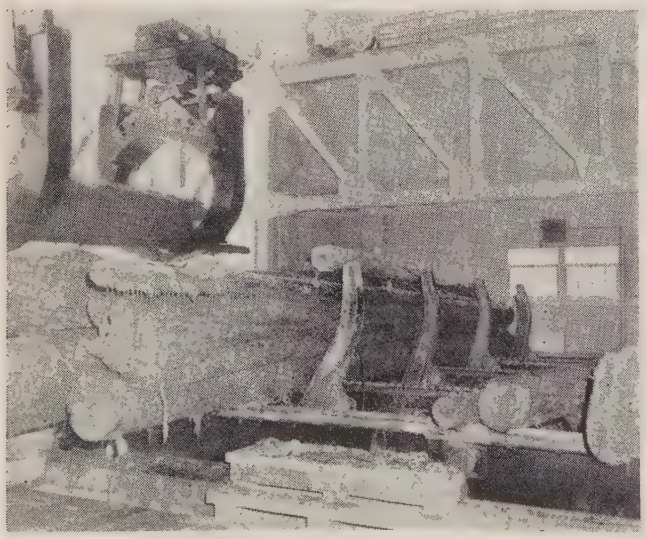
Some six years ago, equipment was developed in the Northwest which resulted in a radical change in the method of processing wood for the pulp and paper industry. Fundamentally, these changes were, first—the development of the hydraulic barker, and, second—of whole log chippers. The new wood mill at Camas embodies the latest design of such equipment together with other equipment especially designed for our operation.

Until a few years ago, all logs were received at the mill in flat rafts. Recently, however, due to the change in logging methods, we have been receiving a considerable portion of our logs in the form of bundle rafts. With this method, a complete truck load of logs is banded wtih strap iron and lowered into the river. State regulations regarding load limits on highways have, in general, restricted the



Crane grapples preparing to pick up a log bundle. Covers have been removed from the hydraulic pump compartment

weight of these individual bundles to 40,000 pounds. However, the Crown Zellerbach Corp. has recently built private logging roads upon which there are no state restrictions as to load limit, and it is presumed that individual bundles of logs weighing up to 100,000 pounds will have to be handled at the mill. The handling of bundle type rafts at the mill in the past has presented a problem in that upon breaking the bands some of the logs would sink. Prior to the application of the bundle type raft, the sinker problem

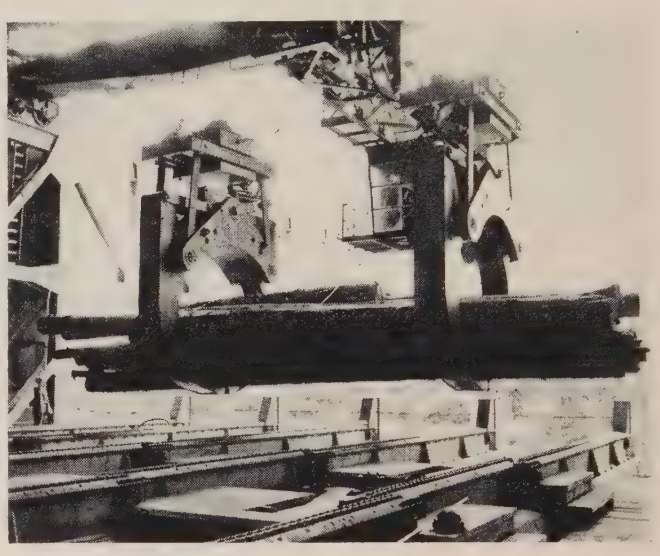


Bundle on log deck and arms which hold bundle while the straps are cut

was confined mostly to the raft booming areas at the logging operations. Transferring of this problem to the mill operations caused considerably trouble to the extent that it has been necessary to bring in a digger barge about once a month to remove sinkers from the log pond.

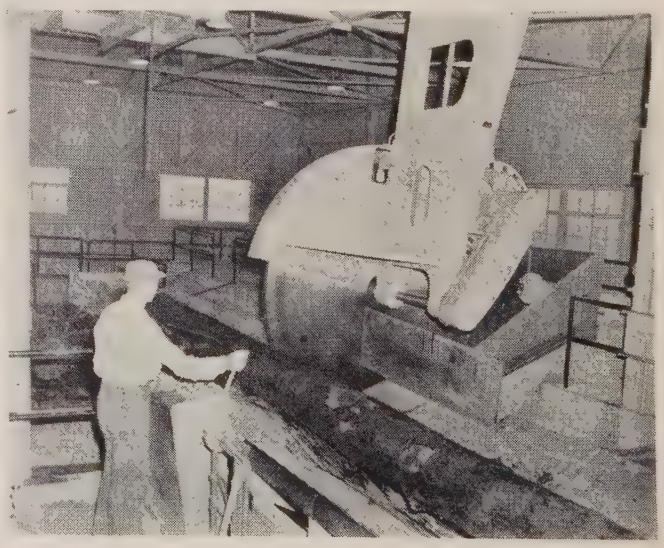
To eliminate this problem, the equipment for handling logs to the deck of the new mill is designed along radical lines. The new mill does not have the conventional type of log haul, or even the par buckling type of hoist which is used in a few mills. Instead it is equipped with a Berger Engineering Co. bridge crane having two hydraulically operated log grapples either of which may be raised or lowered independently.

A Berger warping hoist is provided to move the log rafts under the bridge crane and grapples. This is a two drum hoist driven by a 25-hp. wound rotor induction motor and provides for speeds of 2 feet per minute, 5 feet per minute and 20 feet per minute on the hauling line, and 100 f.p.m. on the haul-back line. It is remotely controlled some 150 feet away by the boom men.



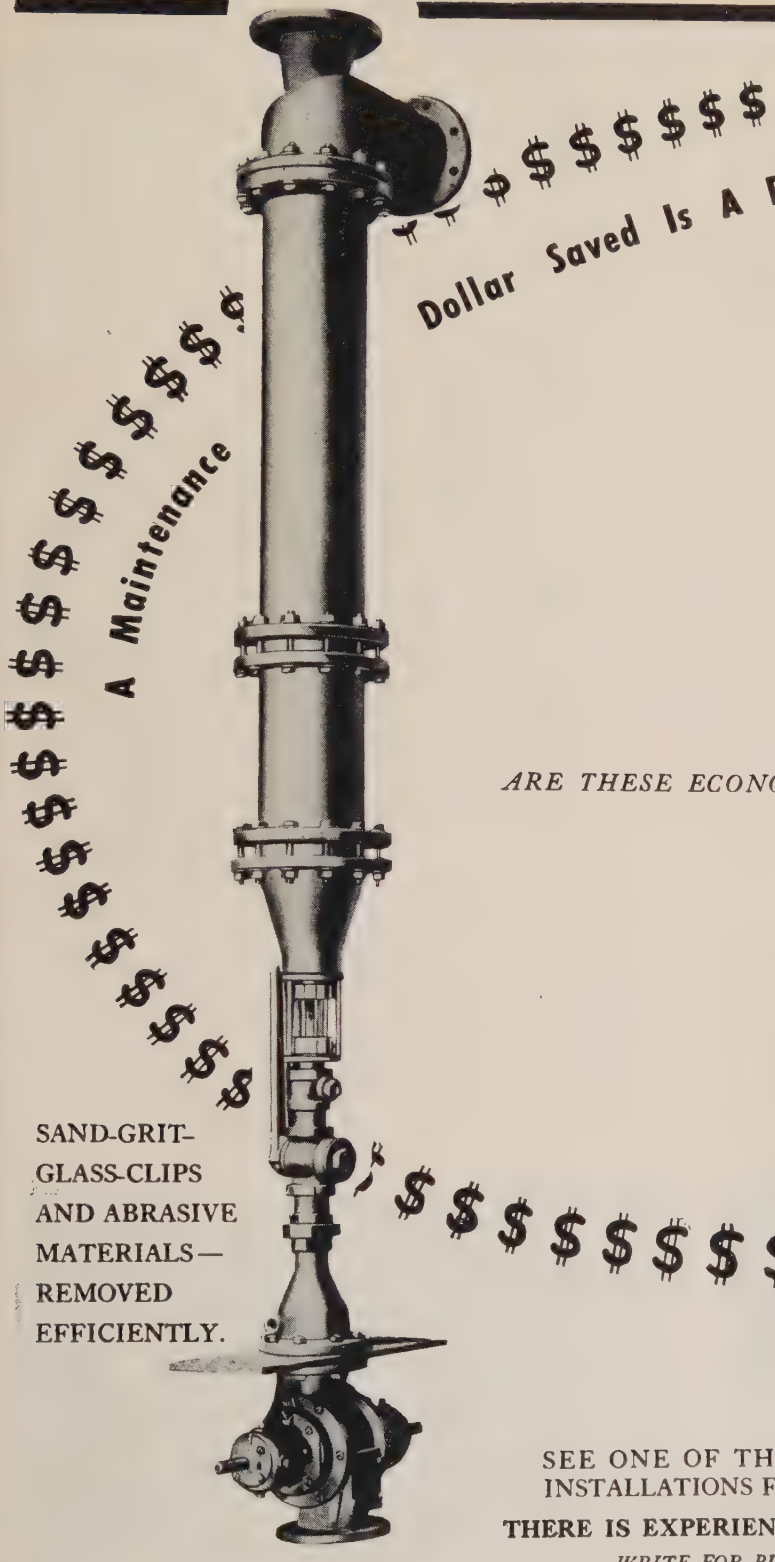
Bridge crane preparing to set load on log deck. (Note size of man at lower left)

The bridge craneway is approximately 270 feet long, 200 feet being above the log deck, and 70 feet being cantilevered over the waters of the Camas slough. The crane and grapples are designed to handle bundle rafts up to 65 feet in length having a net weight of 100,000 pounds. The bridge crane rails are located at an elevation of 95 feet and the log deck at an elevation of 63 feet. These elevations



108-inch cut-off saw

VORTRAPS



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WRITE FOR BULLETIN NO. 219-C

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are above the zero level of the river. The water level ranges from a minus 2 feet to a plus 38 feet, but is normally around a 10 foot stage. The hoists are designed for full hoisting speeds of 25-40-70 and 146 f.p.m. with a bridge speed of 100 f.p.m., and a trolley travel of 80 f.p.m. Hoisting power is provided by two 100-hp. wound rotor induction motors, one for each grapple, with Westinghouse reactor type control. The 13 ton grapples are opened and closed hydraulically by means of a 40-hp. motor-driven pump mounted in a waterproof casing on the grapple itself. The motor is supplied from a drum carrying tyrex cable which pays out or reels in at the same rate that the grapples travel. The grapples open to 14 feet wide, and when closed, will encompass a bundle of logs up to 10 feet in diameter, and can also pick up logs from a flat raft. The capacity of this equipment for handling logs will range from 50,000 f.p.m. per hour when handling small loads of around 30,000 pounds net to a capacity of 90,000 f.p.m. per hour when handling heavy loads in the range of 80,000 pounds net. These capacities are established under maximum lift conditions, that is, when the river is at its lowest stage.

The bundles of logs are deposited by the crane on the transfer chains of the log deck. These chains carry the bundle to a series of pneumatically controlled arms which can be raised or lowered from the floor to encompass the bundle and hold it while the bands are cut. Upon removal of the bands, the rear set of bundle arms are lowered, allowing the logs to spill out on the transfer chains of the log deck. From this point, the logs are transferred to the swing cut-off saw. This saw is a 108 inch diameter circular saw driven by a 75-hp. motor. Here the logs are cut into 24 foot lengths, and are discharged to the transfer chain which feeds the hydraulic barker.

The hydraulic barker is a modified Bellingham type. The modifications are embodied in the design of the nozzle arrangement, and the entire barker control system as a result of experience gained from the operation of a pilot unit designed by the Camas Engineering Dept. This unit has been in operation for the past two years at the old wood mill. The barker control is designed to rotate an 84 inch diameter by 24 foot long log in the trunnions at any selected speed from one to forty r.p.m. in either direction, and to move the nozzle carriage along the rotating log in a forward or reverse direction at any desired barking speed. The nozzle can be raised or lowered pneumatically through a range of 78 inches. Stepless speed control of trunnions and nozzle carriage is obtained by direct current motors having Westinghouse Rototrol regulators. An outstanding feature of the control is the airplane type operating wheel which houses all the necessary switches and devices to fully control the barker and make operating simple and convenient.

Following the hydraulic barker operations, the logs are discharged to a transfer chain which moves them to the spudding and inspection station. This is another piece of equipment which was designed especially for the Camas Mill and has never previously been used in any other wood operations. Instead of spudding the logs as they travel on the transfer chain which is the general practice in most mills, in the Camas operation the log is first transferred to a conveyor having a set of corrugated "V" rolls. In the space between the rolls is a pneumatically controlled arrangement of chains and sprockets which allows the log to be lifted up off the "V" roll conveyor and rotated slowly. Any necessary spudding is done at this station, following which the log will be lowered again and conveyed through the log washer.

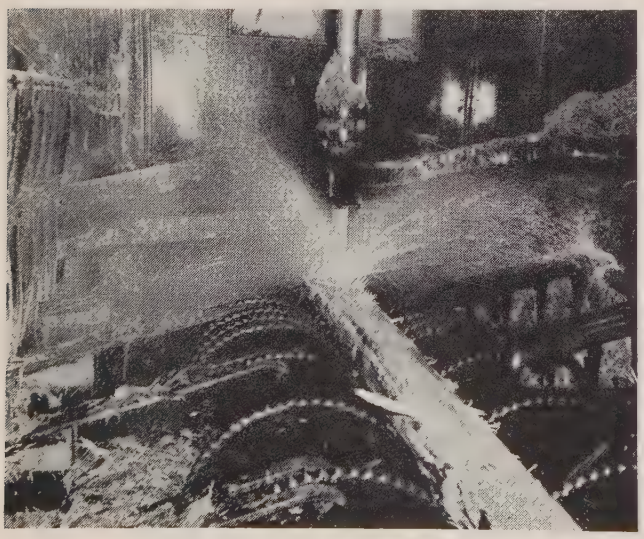
The log washer washes the entire log with six high-pressure nozzles. From the washer, the logs are delivered to the chipper transfer chain.

The whole log chipper is a Sumner 6 knife—153 inch diameter two anvil chipper driven by a 1500-hp., 7000-volt synchronous motor. Logs up to 34 inch diameter can be processed by this chipper. One of the most remarkable features of these whole log chippers is their capacity. This 153 inch chipper, if supplied with logs of 30 inch diameter end to end in a continuous stream, would convert to chips over 200,000 feet board measure of logs each hour. The Camas Mill maximum daily requirements are approximately 650,000 f.p.m. This is the first of the large log chippers above 110 inch diameter to be equipped with a sloping bed knife. This change was made in the expectation of obtaining a quality of chip that would compare with the 110 inch and smaller chippers. Chips are discharged from the chipper to a 72-inch width rubber belt conveyor which transfers the chips to concrete chip storage silos.

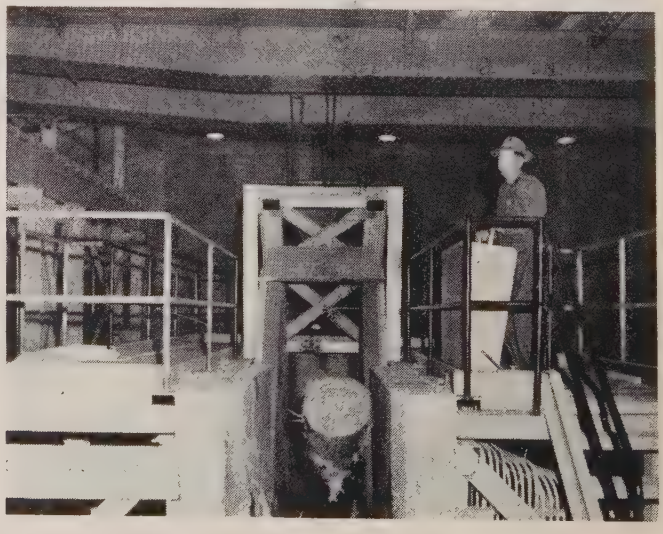
There are four of these silos, each 44 feet in diameter by approximately 75 feet high. Each silo has a capacity of approximately 400 units of chips. Chips are discharged from the silos by Link Belt mechanical feeders to a 42 inch belt conveyor which transports them to the screen room.

The screen room is equipped with four 6 feet by 16 feet Allis-Chalmers double deck vibratory type screens, and space has been made available in the screen room building for an additional screen if and when it becomes necessary. A 36-inch Sumner disk-type rechipper is installed.

From the screen room, chips are transported eastward by 36-inch belt conveyors and then northward across the



Hydraulic barker (log in)



Log entering whole log chipper

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S. P. & S. railroad tracks and east again to tie in with the conveyors from the old Chip Plant to the pulp mills.

Some of the auxiliary equipment at the new mill is also worthy of mention. The Worthington pump for supplying the hydraulic barker is designed for capacity of 1200 GPM and 1300 pounds pressure. The pump is driven by a 1250 hp., 7000-volt squirrel cage induction motor. A 1000 cu. ft. per minute duplex air compressor driven by a 200-hp. synchronous motor provides compressed air at 125 pounds pressure for the operation of the various control cylinders throughout the wood mill. A 62-foot span bridge crane with capacity of 40 tons is installed over the 153-inch chipper. This was primarily purchased for the installation of the chipper, but will be available in the event of a major maintenance job on the chipper.

A Sumner No. 65 Vee-type hog is installed in a separate building adjacent to the wood mill, and space is provided for a second unit if and when desired. The hog is driven by a 200-hp. motor.

Power is supplied by one 7200 volt line and one 2300 volt line. 7200 volt service feeds the barker pump motor and chipper pump motor direct, and, in addition, the 550-volt load center. The 2300 volt service feeds the air compressor motor, hog motor, and 72-inch belt drive. Switchgear, load centers, motors, and control were furnished by Westinghouse.

Log and transfer chains were supplied by Sumner Iron Works, gear reduction units were manufactured by Western Gear Works.

The first stage of the new wood mill does not include a head rig for breaking down large logs to the 34-inch size of cant which the chipper can handle. As a result, it will be necessary to run a part of the old wood mill on large logs.

Eventually a head rig, supplementary barking equipment, and possibly one smaller chipper will be added to allow discontinuing all operations at the old wood mill. Four additional chip storage silos are also contemplated in the final scheme.

The differences between the method of preparing wood in the old and new wood mill might be interesting, and can best be exemplified by considering the handling of a log 30 inches in diameter and 24 feet in length. (In the new mill, it would not be necessary to put a saw cut in this log at all. It would be barked and chipped in the whole log form.)

In the old mill, such a log would first go to the band saw

Chips discharging from screen. (Note very few oversize chips or cards leaving the top plate)

head rig. Here two saw cuts would be made cutting the log into 10 inches by approximately 30 inches by 24 feet slabs. The slabs would then pass through the edger saws where each slab would have two more saw cuts made. Thus, from the edger would come 9 cants approximately 10 inches $\times$ 10 inches $\times$ 24 feet. The cants would then pass through the slasher saws where eleven more cuts would be made converting each cant in blocks of wood two feet in length. Thus, a total of 107 saw cuts would be necessary to break down the log into 108 blocks of wood. As the width of the saw cuts vary for $^1/_4$ to $^3/_8$ inch, one can easily appreciate that there is a considerable loss of wood from saw kerf.

Ninety-six of the 108 blocks will have bark on one side and must pass through the drum barker. Here the bark is removed by tumbling the blocks in a rotating drum. It is necessary to inspect all blocks discharged from the drum barkers, and it is also necessary to sort and return to the drum barkers for rebarking from 30 to 50% of the blocks depending upon the tightness of the bark.

Accepted blocks from the barkers and inside wood blocks are routed through conveyors and then by flume to the old chipper plant about $^1/_4$ mile away.

TAPPI Fourth Engineering Conference Group During Visit to Norton Co., Lodding Engineering Co., Riley Stoker Co. and Rice Barton Corp., Worcester, Mass., November 3, 1949

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PERSONAL MENTION

New Tappi Members

Richards G. Anderson, Sales Engineer, Thiele Kaolin Co., Sandersville, Ga., a 1948 graduate of the University of Wisconsin.

Walter I. Barrows, Owner, W. I. Barrows & Associates, Consultants, Dayton, Ohio, a 1909 graduate of Worcester Polytechnic Institute.

J. Roland Brown, Jr., District Manager, Bingham Pump Co., Seattle, Wash.

Charles E. Cashman, Jr., Chemical Engineer, Crocker, Burbank & Co., Fitchburg, Mass., a 1933 graduate of Massachusetts Institute of Technology.

Corienne Casper, Librarian, United States Gypsum Co., Chicago, Ill., a 1926 graduate of Baker University.

Mario C. Celli, Project Manager, The Rust Engineering Co., Pittsburgh, Pa., a 1932 graduate of Carnegie Institute of Technology.

Dudley F. Church, Chemical Engineer, Kraft Mill, Crown Zellerbach Corp., Camas, Wash., a 1947 graduate of Massachusetts Institute of Technology.

William E. Damon, Factory Representative, The Orr Felt & Blanket Co., Piqua, Ohio. Attended Hastings College and the University of Wisconsin.

Franklin L. Darrell, Plant Engineer, International Paper Co., Ticonderoga, N. Y., a 1912 graduate of the University of Maine.

Clifford A. Flanders, Assistant Biochemist, West Virginia University, Morgantown, W. Va., a 1934 graduate of Columbia University.

Fred Folmer, Associate Librarian, University of Texas, Austin, Tex.

Sakae Fukuyama, Director, Honshu Paper Mfg. Co., Ltd., Tokyo, Japan, a 1923 graduate of Kyushu University, Japan.

Madeleine Gibson, Librarian, Michigan College of Mining & Technology, Houghton, Mich.

John T. Hegeman, Research Chemical Engineer, Congoleum Nairn, Inc., Cedarhurst, Md., a 1944 graduate of Worcester Polytechnic Institute.

Leon E. Hoogstoel, Technical Director, Behr-Manning Corp., Troy, N. Y., a 1926 graduate of the University of Pennsylvania.

Edward Hutchins, Consulting Engineer, Carmel, Me., a 1903 graduate of Worcester Polytechnic Institute.

Court L. Koerner, Resident Plant Engineer, Marathon Corp., Rothschild, Wis., a 1928 graduate of the University of Washington.

Frantisek Kozmal, President, Czechoslovak Paper & Woodpulp Mills, Prague 1, Czechoslovakia, a 1921 graduate of the Technical University.

Derk G. Landweer, Managing Director, Scholtens Board & Paper Mills, Groningen, Holland.

Leo P. Newton, Assistant Mill Superintendent, Rushmore Paper Co., Gouveneur, N. Y.

Douglas B. Orr, Technical Representative, Aero Research Ltd., Duxford, Cambridge, England.

Lester L. R. Phillips, Jr., Research Chemist, Hurlbut Paper Co., South Lee, Mass., a 1940 graduate of Massachusetts State College.

Louis J. Philipps, Assistant Engineer, Michigan Carton Co., Battle Creek, Mich., 1943 graduate of Illinois Institute of Technology.

Eric S. Prior, Mill Controller, Oxford Paper Co., Rumford, Me., a 1936 graduate of New York State College of Forestry.

Harry A. Raddin, Chemical Engineer, Miller & Collins, Inc., Richmond, Va., a 1935 graduate of Norwich University, with an M.S. degree from Stevens Institute of Technology in 1942.

Walter Reimerdes, Paper Mill Agent, New York 19, N. Y.

Boris R. Rubens, Partner, Stevenson & Rubens, Consultants, Seattle, Wash., a 1935 graduate of Darmstadt College, Germany.

Niilo E. Ryti, Technical Manager, G. A. Serlachius Oy, Jyvaskyla, Kangas, Finland, a 1944 graduate of Technical University.

Sven A. Salmonson, Sales and Representative, Chemipulp Process, Inc., Watertown, N. Y.

Rex W. Snow, Chemist, Blandin Paper Co., Grand Rapids, Minn. Attended Eau Clair (Wis.) State Teachers College.

Leonard P. Stewart, Jr., Administrative Assistant to Research Director, The Drackett Co., Cincinnati, Ohio, a 1937 graduate of the University of Cincinnati; and a 1947 graduate of Chase Law College.

V. D. Tate, Director of Libraries, Massachusetts Institute of Technology, Cambridge, Mass.

B. A. Poulie Wilkins, Managing Director, N. V. Stroostoffabriek "Phoenix," Veendam, Holland, a graduate of the Commercial College, Rotterdam; and of the Technical High School.

Erich K. Zimmermann, Director, Technical Service Laboratories, Titanium Pigment Corp., New York, N. Y., a 1927 graduate of Lehigh University, with an M.S. degree in 1928.

TAPPI Notes

Harold R. Alley, formerly of the Chicago Show Printing Co., is now Industrial Specialist, Economic Scientific Section, Chief of Consumer Goods Unit, Army of Occupation, Tokyo, Japan.

Khursheed, Ali, formerly of Sirpur Paper Mills, Ltd., is now Special Officer for the Paper Industries, Ministry of Industries, Karachi, Pakistan.

Alexander V. Alm, formerly of American Cyanamid Co., is now located at 2 Weston Road, Marblehead, Mass.

Earl F. Anderton, formerly of the Marinette Paper Co., is now a member of the Technical Service Staff, Scott Paper Co., Chester, Pa.

J. R. Atwater, Asst. to the President, Mead Sales Co., has been transferred from New York City to Dayton, Ohio.

Harry P. Austin, formerly of the St. John Sulphite Co., is now with St. Raymond Paper Ltd., Desbiens, P. Q.

Bruno H. Baldacci, formerly of the University of Maine is now Chemist for Bemis Bro. Bag Co., Peoria, Ill.

Cecil H. Baldwin, formerly of Scott Paper Co., is now Asst. to the Technical Director, Marinette Paper Co., Marinette, Wis.

W. R. Barber of the Crown Zellerbach Corp., has been transferred from Camas, Wash., to San Leandro, Calif., where he is Technical Director for the Western Waxed Paper Co., Division.

Thomas M. Barry, formerly of Fraser Paper Ltd., is now Asst. Manager of Northern Mills, Hollingsworth & Whitney Co., Waterville, Me.

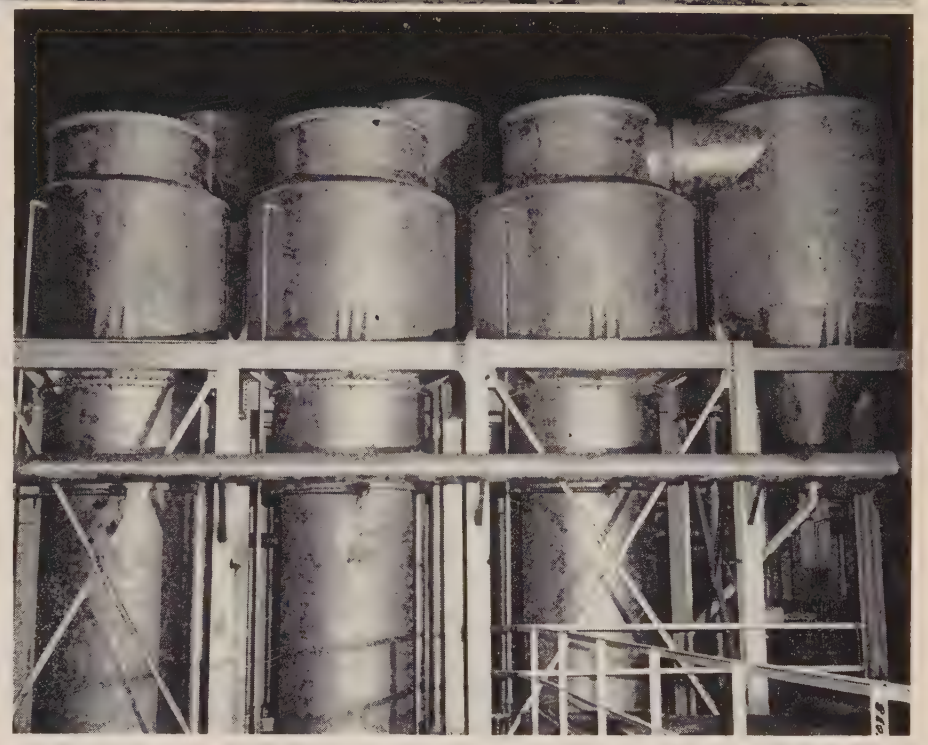
Harry Bennett, Eastern Manager, Valley Iron Works is now located at 2418 Polk St., Hollywood, Fla.

Norman J. M. Bennett, Manager of Bridgend Paper Mills, Ltd., is now located at Glamorgan, South Wales.

Murray H. Bennett has announced the removal of Chem-

Composite view of main Goslin-Birmingham plant at Birmingham, Ala.

MULTIPLE EFFECT EVAPORATORS



Partial view of sextuple effect Black Liquor Evaporator now in operation.

G-B Long Tube Vertical Evaporators, designed and built in our modern plant, are fast establishing themselves as standard equipment in the recovery process of soda and sulfate pulp mills.

G-B Black Liquor Evaporators, designed for specific requirements, are built to insure low operating and maintenance costs.

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ical Linings, Inc., to 500 Trust Company Bldg., Watertown, N. Y.

Alex F. Brobesky, formerly of Mengel Co., is now Research Engineer for Dilts Machine Works, Fulton, N. Y.

Herbert A. Brawn, formerly of the Moraine Paper Co., is now Superintendent, Monadnock Paper Mills, Inc., Bennington, N. H.

Robert E. Burkhardt of the St. Regis Paper Co., is now General Superintendent of the Kalamazoo, Mich., Mill.

Harvey P. Cannon is at present in the Muhlenberg Hospital, Plainfield N. J.

Wayne E. Case, formerly of Time, Inc., is now with the Sutherland Paper Co., Kalamazoo, Mich.

Harry K. Collinge is now General Manager, Canada Paper Co., Montreal, P. Q.

Henry C. Crandall is now Technical Director, Mosinee Paper Mills Co., Mosinee, Wis.

John D. Davis is now Asst. to the Vice-President in charge of Operations, The Mead Corp., Chillicothe, Ohio.

Charles T. B. Ezard, formerly of the Trinidad Paper Pulp Co. Ltd., is now Asst. to the Chief Engineer, Cellulose Development Corp. Ltd., Hatch End, Middlesex, England.

Kristian Fougner, formerly with the Kennebec Pulp and Paper Co., is now Asst. to the Technical Director, A/S Borregaard, Sarpsborg, Norway.

T. H. Frankel, formerly with Wiggins Teape & Co., Ltd., is now Director, Bridgend Paper Mills, Ltd., London, England.

Milton J. Gordon is now Research Chemist for Peter J. Schweitzer, Inc., Elizabeth, N. J.

Burton H. Greenwood, formerly of Thomas W. Dunn Co., is now Owner of the Burtonite Co., Nutley, N. J.

Theodore J. Gross, formerly of the Shipping Container Institute is now Technical Adviser, Union Bag & Paper Corp., New York, N. Y.

Mohammed A. Hadi is now Chemist for the Sirpur Paper Mills, Ltd., Hyderabad-Deccan, India.

Earl G. Hallonquist, formerly of the Plymouth Research Foundation is now Wood Technologist, Division of Industrial Research, Washington State College, Pullman, Wash.

A. F. Hartman, formerly of George F. Hardy, Inc., is now retired and living at 20 Daily St., Nutley, N. J.

Gustaf Jacobsen is now Cost Engineer, St. Regis Paper Co., Deferiet, N. Y.

J. D. Jenssen, Consulting Engineer, is now located at 19 Rector St., New York, N. Y.

William S. Kennedy, formerly of the Bristol Co., is now Midwest Sales Manager, Paul Valve Co., Milwaukee, Wis.

Herman Koerwitz, formerly of the Marathon Corp., is now Engineer for the Chicago Cardboard Co., 670 W. Washington Blvd., Chicago, Ill.

Olavi Laurola, Technical Adviser of the Finnish Cellulose Association has been transferred from New York, N. Y., to Helsinki, Finland.

Otto E. Lohrke, Jr. of the Riegel Paper Corp., has been transferred from Milford, N. J., to the Sales Dept., 342 Madison Ave., New York, N. Y.

Lennart A. Lundberg of the Pulp Div., Weyerhaeuser Timber Co., has been transferred from Longview, Wash., to Springfield, Ore., where he is a Digester Cook.

George E. Martin is now Asst. Technical Director, Mosinee Paper Mills Co., Mosinee, Wis.

Frank J. McCourt is now Sulphite Superintendent, International Paper Co., Palmer, N. Y.

John A. McPherson is now Asst. Plant Manager, Mosinee Paper Mills, Mosinee, Wis.

Harold M. Morris, formerly of the Mobile Paper Co., is now Board Mill Superintendent, Champion Paper & Fibre Co., Pasadena, Tex.

Edward K. Mullen is now Salesman, Robert Gair Co., Haverhill, Mass.

S. C. Nagel, formerly of the Monsanto Chemical Co., is now Resin Chemist, Chemical Div., The Borden Co., Bainbridge, N. Y.

Arthur W. Neubauer, formerly of the Glidden Co., is now with Crown Zellerbach Corp., Camas, Wash.

Karl A. Oberreich has joined the Sales Staff of Appleton Woolen Mills, Appleton, Wis.

Ellis F. Parmenter, Research Chemist for the Champion Paper & Fibre Co., has been transferred from Canton, N. C., to Hamilton, Ohio.

R. David Ragle, formerly of the Colorado University is now a Groundwood Tester, Longview Fibre Co., Longview, Wash.

H. A. Simons, formerly with Bloedel, Stewart & Welsh, Ltd., is now a Consulting Engineer, 16 E. Hastings St., Vancouver, B. C.

Allan G. Strang is now Chief Chemist and Parchment Superintendent, Columbia River Paper Mills, Vancouver, Wash.

Jay J. Uber is now Vice-President in charge of Research, Texon, Inc., Russell, Mass.

Erik Ungern, formerly of Tervakoski Paper Mill in Finland is now Asst. to the Technical Superintendent, Howard Smith Paper Mills, Ltd., Cornwall, Ont.

Robert T. Van Derveer, formerly of the N. Y. State College of Forestry, is now Paper Chemist for NOPCO Chemical Co., Harrison, N. J.

Arthur G. Wakeman is now Coordinator of Engineering, Process Development and Expansion, Coosa Newsprint Co., Coosa Pines, Ala.

S. E. Walmsley, formerly of Bowater's Paper Mills Ltd., is now Consulting Engineer for Hitchins, Jervis & Partners, Westminster, London, England.

Kurt Wandel is now President of Kurt Wandel Industries, Inc., Downingtown, Pa.

John C. Wilson is now Asst. to the Manufacturing Superintendent, Hammermill Paper Co., Erie, Pa.

William R. Willets has succeeded G. W. Corddry as official representative of the Titanium Pigment Corporation in the Technical Association.

* * *

Recent foreign visitors to the United States include:

Niilo Ryti, Technical Manager, G. A. Serlachius Oy., Kangas, Finland.

A. J. Colville Aikman, Glory Paper Mills Ltd., Woodburn Green, Bucks., England.

Harold N. Baker, Director, Thames Board Mills Ltd., Purfleet, Essex, England.

* * *

The new Central Research Laboratory of the Marathon Corp., at Rothschild, Wis., has been opened. Allen Abrams, Vice-President in charge of Research, states that the new laboratory will be used for both fundamental and applied

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research pertaining to the company's products and processes; particularly those relating to wood, pulp, paper, and lignin products. Research investigations relating to converted products will continue at Menasha under the direction of D. W. Davis. G. J. Brabender is assistant to Dr. Abrams and J. R. Salvesen is Director of Research for the Central Laboratory.

The new building is constructed of structural steel, reinforced concrete and brick, with Indiana limestone trim. The windows are hermetically sealed double glass, for insulation, and the building is air conditioned. Aluminum hardware and metal work are used throughout the building. Floor covering is a light gray asphalt tile. Fluorescent lighting provides 50 foot candles of light at the working surfaces in laboratories and offices. Laboratory furniture is constructed of birch in a golden brown finish having table tops with a treated wood surface to resist attack by chemicals and solvents. The principles of color harmony employed in decorating the building produce a pleasing appearance and enhanced functionality of the laboratory.

There are three floors, each containing approximately 8000 square feet. The first floor houses the constant temperature and humidity room, a machine shop, storage facilities, and two pilot plants, of which one is two floors in height. The second or main floor is reached through the front entrance. As the visitor enters the reception room, his eye is caught by a mural depicting the application of science to the pulp and paper industry. On the same floor are the conference room, library, offices, and two laboratories.

The third floor has three offices and a storeroom, the remaining space being occupied entirely by laboratories, dealing with organic, analytical, physical, and biological chemistry.

* * *

Industry Notes

The National Forge and Ordnance Co., Irvine, Warren Co., Pa., has issued a Brochure 492 M on their new 750-pound capacity compression testing machine for making crush tests on boxboard and flexure and compression tests on small containers.

* * *

Victor W. Bloomer is now President of the Appleton Machine Co., succeeding Henry P. Madsen, deceased. Richard Radsch is Vice-President in charge of Sales.

* * *

Jesse M. Holderly, Research Coordinator of the Sulphite Pulp Mfgrs. Research League, N. L. Malcove, Northern Paper Mills, and Frank H. Coldwell, Nekoosa-Edwards Paper Co., are visiting Sweden, Germany and England to inspect the progress in the disposal of spent sulphite liquor and the production of food and feed yeast.

* * *

The following postgraduate fellowship awards in the Division of Industrial and Cellulose Chemistry at McGill University for the season 1949–1950 have been announced:

Allied Chemical & Dye Corp., Fellowship—D. F. Manchester (Queens)

American Viscose Corp., Sylvania Division Fellowship (N. Y. State College of Forestry)

Brown Corp., Fellowship—N. Levitin (Queens)

Canadian Industries Ltd., Fellowship—D. A. Guthrie (Manitoba and Toronto)

D. S. and R. H. Gottesman Foundation Fellowship—John A. Harpham (Toronto)

OBITUARIES

John Brooke Shaughnessy

J. Brooke Shaughnessy died recently at his home in Granville, Mass. Mr. Shaughnessy was consultant for the American Wringer Co., Woonsocket, R. I., on paper decorating and finishing. He was born in Philadelphia, Pa., on April 11, 1900 and was graduated as a mechanical engineer from the Armour Institute of Technology in 1920. Prior to joining the American Wringer Co., in 1934, he was employed as an engineer by James H. Matthews & Co., Mornell Steel Products Co., Wilson Imperial Co., and the Texas Co. Mr. Shaughnessy became a member of the Technical Association in 1945.

Edwin F. Bearce

Edwin Freeman Bearce, Vice-President in charge of Production and Chief Engineer of the Chillicothe Paper Co., Chillicothe, Ohio, died suddenly of a coronary occlusion on November 11, at his home in Chillicothe.

Mr. Bearce, who was a former member of the Executive Committee of the Technical Association was born at Auburn, Maine, on Feb. 2, 1882, and graduated from the University of Maine in 1905.

In 1914 he became chief engineer for the Mead Pulp and Paper Co., in Chillicothe, when their mill was being built. In 1919 he became chief engineer of the Chillicothe Paper Co., which was under construction.

A few weeks prior to his death the Ohio Society of Professional Engineers conferred on Mr. Bearce its "Outstanding Engineer" award. He was very active in the field of water conservation and flood control. In this connection he served on the organized committee of the River Sanitation Commission and was a director of the Ohio River Water Conservation and Flood Control Congress.

Henry P. Madsen

Henry P. Madsen, 50, President and General Manager, Appleton Machine Co., Appleton, Wis., died of a heart attack while playing golf on the Butte des Morts Golf Course, near Neenah, Wis., on October 20. Mr. Madsen was the official representative of the Appleton Machine Co., in the Technical Association.

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2. **No serious waste liquor problem.**
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The above advantages result in a saving in production costs, increased yield from available wood, and superior qualities in specific grades of paper when you bleach with Pennsalt Hydrogen Peroxide. Such paper finds popular application in items of transitory nature—such as magazine, catalog, directory, mimeograph, tablet, tissue, toweling, book and hanging papers. That's why more and more paper manufacturers are showing interest in bleached groundwood . . . bleached with Pennsalt H_2O_2!

An experienced Pennsalt representative may show you how to use Hydrogen Peroxide to advantage in your bleaching operation. Write: *Heavy Chemicals Division,* ***Pennsylvania Salt Manufacturing Company,*** *Philadelphia 7, Pa.*

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Dicalite improves formation—not by chemical means because it is inert—but by physical action of causing a more thorough and uniform dispersion of fibers at the wet end during formation. This action is peculiar to diatomaceous earth, due to the structure of the particles. We will be glad to mail you full information or send a representative on request.

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LETTERS TO THE EDITOR

Stock Flow in Pipes (Erratum)

To the Editor *Tappi:*

In the publication of "Stock Flow in Pipes Round Table," *Tappi* 32, No. 9: 53A (Sept., 1949), the published discussion contained several typographical errors which should be called to the attention of readers interested in this subject. These errors all involve the omission of the symbol for the Greek letter phi. In the first paragraph, in the sentence beginning, "It was suggested. . . .," the first comma had been substituted for the Greek letter phi. Similarly, this symbol was omitted or replaced by a comma in several subsequent sentences. The most serious omissions, however, were from formulas and the table given on page 70A. The corrections are, in order, $H = 400\phi/wD$; $\phi = wDH/400 = HD/6.4$; in the next to last line, first column, page 70A, ϕ should be inserted before "is"; the first heading of Table A should read, "Friction factor based on Hayton's data, ϕ in lb./sq. ft., etc."; the last correction of importance is in the second paragraph following the table: the third sentence of that paragraph should read, "The loss for 100 feet of pipe could then be obtained by computing $6.4\phi/D$, in which D is expressed in feet."

J. A. Van den Akker, *Research Associate*
Institute of Paper Chemistry, Appleton, Wis.

Reporting of Test Results

To the Editor *Tappi:*

It is disconcerting to see occasional papers dealing with pulp tests published in *Tappi* or presented to a meeting of the Association, having derived test units given other than in accordance with TAPPI Standard T 220 m.

As a result of a TAPPI membership poll in 1948 the majority (52%) were in favor of having pulp tests reported in accordance with T 220 m and the other 48% were divided mainly between systems based on 24 × 36—480, 24 × 36—500, and 25 × 40—500 pound reams.

T 220 m, which deals with reporting *derived* pulp test results (not *direct* results such as burst and thickness, etc., which remain offically on the old basis of p.s.i. and mils etc.) is based entirely on the metric system and corresponds with the official standards for pulp tests in Canada, Great Britain, Scandinavia, and other European countries as well as India and Australia.

With this weight of opinion in its favor it would seem proper, for the sake of clarity and better understanding, for TAPPI to require, as do most other technical societies, that data presented in papers should conform with its official standards.

In order to help to interconvert the various pulp tests until everyone reports and thinks in terms of TAPPI Standard T 220 m or the International Standards, the following table is offered.

James d'A. Clark, *Chairman*
Testing Division, TAPPI

EMPLOYMENT SERVICE

Positions Open

P36-49. Sales Engineer. Papermaking machinery firm in New England. Engineering school or pulp and paper course education. Some mill experience. Age under 36.

P38-49. Chief draftsman and engineer. Engineering degree. 35–45. New England mill making sulphite and kraft pulp and paper.

P39-49. Machine Designer. Prominent manufacturer of pulp and paper mill machinery has opening for experienced design engineer. Give full details education and past experience in first letter.

P40-49. Color room foreman for Coating Mill located in New England. Give details of experience.

P41-49. Young man in 20's. Training position leading to sales work open with prominent dyestuffs concern.

Positions Wanted

E34-49. Chemist. Paper technologist with engineering experience. 33, B.A. Chem. 10 years' research and 2 years' industrial experience, including quality control and statistical analysis.

E49-49. Electrical engineer. 26, B.S.E.E. Two years' research experience. Desires position in northern mill.

E50-49. Chemist. 33, B.A. Chem. 11 years' experience in insulating board mill. Knowledge of coatings, fire retardents, laminating, adhesives.

E51-49. Engineer. 47. S.B. Civil Eng. M.I.T. 21 years' experience in bleached kraft mill as draftsman, master mechanic, steam plant superintendent, design and chief engineer, construction, maintenance, electrical, and steam.

E52-49. Chemist. 37. Fifteen years' experience in pulp and book paper mill and five years with large printing company. Knowledge of manufacture and use of printing papers.

E53-49. Research chemist. Eleven years experience in plup. paper and textiles, especially with problems dealing with pulping, processing, finishing, and dyeing. Research in waxes, resins, and rubber latices for adhesive and color base coatings.

E54-49. Chemical engineering graduate, Canadian, 10 years experience in technical control and research in all types of bleached sulphite pulp.

E55-49. Chemical engineer. Technical and production experience in pulp. Mechanical experience in maintenance and construction. Young, married, excellent references.

Replies should be addressed to box number, % *Tappi,* 122 East 42nd St., New York 17, N. Y.

Multiplying Factors to Convert Pulp Test Data to and from Tappi Standard T 220 m

TAPPI Standard		*24 × 36—480*	*24 × 36—500*	*25 × 38—500*	*25 × 40—500*
Basis weight, g. per sq. meter	To Std.	1.695	1.627	1.480	1.406
	From Std.	0.590	0.614	0.675	0.711
Apparent density, g. per cc. (water = 1)	To Std.	0.0667	0.0640	0.0583	0.0553
	From Std.	15.00	15.62	17.16	18.07
Burst factor, g. per sq. cm. per g. per sq. meter	To Std.	0.415	0.432	0.475	0.500
	From Std.	2.41	2.31	2.10	2.00
Tear factor, g. per g. per sq. meter × 100	To Std.	59.0	61.4	67.5	71.1
	From Std.	0.01695	0.0163	0.0148	0.01405
Breaking length, meters	To Std.	1.00	1.00	1.00	1.00
	From Std.	1.00	1.00	1.00	1.00

Examples:

(1) 60 g. per sq. meter = 60 × 711 or 42.7 lb. 25 × 40—500.
(2) 12.0 density (lb. 25 × 40 ÷ thickness in mils) × 0.0553 = —644 g. per cc.
(3) 1 "point per lb" (26 × 36—480 basis or 100%) = 100 × 0.415 = 41.5 g. per sq. cm. per g. per sq. meter.
(4) 2.00 tear ratio (24 × 36—500 basis) × 61.4 = 128 g. per g. per sq. meter.

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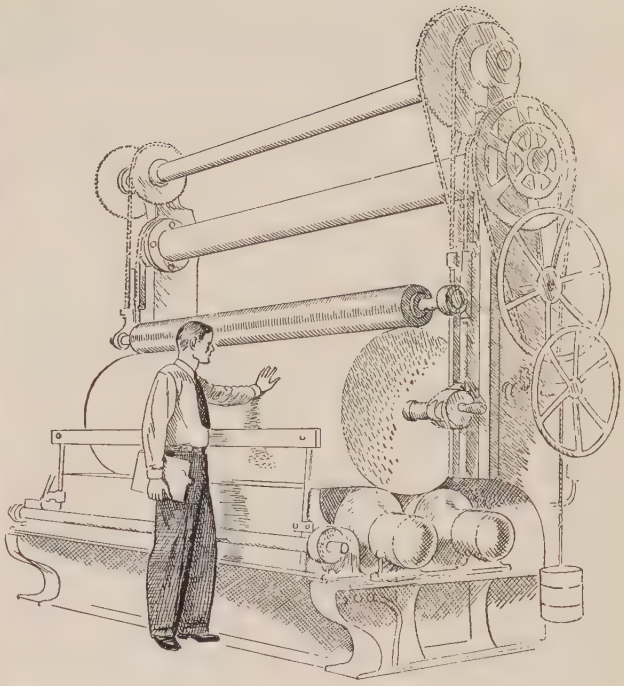

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Butterworth Calender Rolls

REPORTS AND DISCUSSIONS

Presented at National and Regional Conferences

Fibrous Agricultural Residues Meeting

The following is a report of the meeting sponsored by the TAPPI Fibrous Agricultural Residues Committee and held at the Northern Regional Research Laboratory, Peoria, Ill., on November 15–16, 1948. Although the report appears to be late in making its appearance its publication was held up pending the outcome of certain work in progress that is herein reported.

Technical Session—Monday, November 15

Dr. Aronovsky opened the meeting with the usual introductions, and welcomed the group and outlined the program briefly. Then he introduced W. F. Gillespie, Technical Director of the Gaylord Container Corp. and National President of TAPPI.

H. E. Roethe, Assistant Director, Northern Regional Research Laboratory, formally welcomed the group to the Laboratory and outlined the structure and work of this institution.

Mr. Roethe: Thank you, Dr. Aronovsky. Members and guests of the Technical Association of the Pulp and Paper Industry. Dr. Milner, the Director of our Laboratory, regrets that a previous out-of-town commitment makes it impossible for him to be here today. He joins me, however, in extending to you a sincere welcome and in wishing you a most successful meeting on agricultural fibrous residues.

It is gratifying to us to have this symposium held here, because agricultural residues is one of the important agricultral commodities assigned to the Northern Regional Research Laboratory and on which our Agricultural Residues Division is conducting research, looking toward their industrial utilization on a larger scale.

In 1938, the Congress of the United States authorized and directed the Secretary of Agriculture to establish, equip, and maintain four regional research laboratories—one in each major farm-producing area. This authorization stated that the object of these laboratories is to conduct researches into and to develop new scientific, chemical, and technical uses and extended markets and outlets for farm commodities, their products and byproducts. These laboratories were completed during the latter part of 1940. One is located at Philadelphia, serving the eastern region; one at New Orleans for the southern region; one at Albany, California, for the western region; and one at Peoria for the northern region. These laboratories are research agencies. They are not producing or manufacturing products for marketing or distribution, but must rely upon industry to adopt and utilize the processes developed here to manufacture new or improved products. We have approximately 285 employees at the present time. Almost 200 are scientists and technicians.

The agricultural commodities upon which the Northern Regional Research Laboratory is working fall into three groups: Cereal crops, especially corn and wheat; oilseed crops, particularly soybeans; agricultural residues, such as straw, corncobs, hulls, husks, and the like. Our research is organized upon a broad, fundamental basis, and it is carried on through the following eight research divisions, each under the head of a specialist in his field: Agricultural Residues Division, Analytical and Physical Chemical Division, Commodity Development Division, Engineering and Development Division, Fermentation Division, Motor Fuels Evaluation Division, Oil and Protein Division, and Starch and Dextrose Division.

In order to give you a general idea of the kind of research being carried on and to also show the diversity of our program, I have selected a number of the Laboratory's accomplishments which I should like to mention.

Through your close and active association with Drs. Lathrop and Aronovsky and others, I am sure that you are quite familiar with the work of the Agricultural Residues Division on pulps and papers, and perhaps building materials. Therefore, I shall pass over the accomplishments of this Division in this field.

In mentioning the following developments, I have made no attempt to list them in the order of importance: Fundamental research which made possible the commercial production of penicillin; isolation of higher yielding strains of the penicillin-producing mold; surface-culture method for producing penicillin; increasing yield of pencillin by improving the nutrient solution in which the mold is grown; discovery of polymyxin—a new antibiotic of bacterial origin, effective against disease-producing organisms which penicillin and streptomycin are not capable of killing or counteracting; development of a rubber substitute and of a lacquer-like substance from soybean oil; improvement of soybean oil paints; improvement of soybean salad oil; development of a plywood adhesive and of an adhesive for shotgun shell casings from soybeans; development of a process for extracting oil from soybeans, using alcohol as the solvent, which should result in higher quality oil, a meal of improved flavor and color, and now vegetable gel—promising uses for food purposes and as an adhesive; production of a soft-grit blasting material from corncobs for cleaning metals, used by the Navy during the war for cleaning airplane engines; and processing of wheat flour for starch and sweetening agents.

Spinning of textile fibers from the corn protein, zein; development of a process for obtaining sugars from agricultural residues and converting these sugars to useful organic chemicals such as alcohol, acetone, and furfural; development of a fermentation process whereby riboflavin, or vitamin B_2 can be produced cheaply by growing a yeast in an nutrient solution of which the chief ingredients are corn sugar, corn steep liquor, and animal stick liquor; development of a process for using a mold product, fungal amylase, as a complete replacement for malt in converting starch to sugar in the production of alcohol from grain. Use of this fungal amylase should lower the cost of alcohol serveral cents a gallon, which would probably not seem much ordinarily, but would result in a saving of about $500 per day in a plant mashing 5000 bushels of grain; and evaluation of alcohol as a fuel for internal combustion engines. This involves alcohol-water injection into the engine manifold and dual carburetion with alcohol blends. Because of its antiknock properties, alcohol may be used to make a premium grade motor fuel out of low-octane gasoline.

In the prosecution of our research program, and particularly in the field of pilot-plant tests and the industrial application of processes developed at the Laboratory, industry and industrial or technical associations have played an important part.

Early in the last war the Northern Regional Research Laboratory inaugurated the holding of what we might call industrial conferences here at the Laboratory. Their purpose was to bring together, at the proper time, representatives of industry interested in the particular development under consideration so that they could receive first-hand information about the process or product, discuss its merits, and collaborate in determining its commercial possibilities and further development. Since then we have had many such conferences, involving a wide variety of subjects such as butylene glycol, rubber substitutes, thermoplastic resins, wheat alcohol, penicillin, flaxseed, gluten, corn wet milling, corn dry milling, synthetic liquid fuel, and straw collection and baling. These conferences have helped greatly in furthering our research program and in expediting the industrial application of many of the Laboratory's developments.

We welcome the continued interest and support of TAPPI in the work of the Laboratory on agricultural residues, and I hope that this meeting is the forerunner of renewed collaboration between the Association and the Laboratory. I feel very

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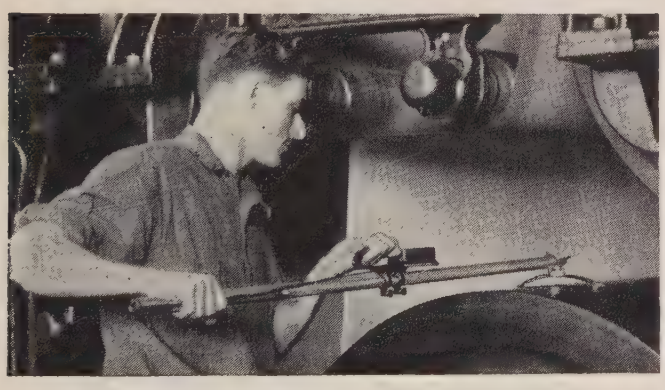

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strongly that such an arrangement and relationship is important to both industry and agriculture.

May I also express appreciation of the splendid work done by the Fibrous Agricultural Residues Committee of TAPPI under the able leadership of Dr. Aronovsky. This committee has proved to be a valuable medium through which the practical solution of some of the complex problems pertaining to the greater and more efficient utilization of agricultural residues will be expedited. Thank you.

The meeting was then turned over to Dr. E. C. Lathrop, moderator of the panel on "Straw Procurement."

Dr. Lathrop: I do not need to emphasize the importance of this collection problem. A good deal of progress has been made, and we are to have a report this morning from some of the committee on various phases of this discussion.

The first talk on the panel is the "Method of Straw Procurement Used by the Alton Boxboard Company" to be given by G. Adair of the Alton Boxboard Co., Alton, Ill.

Mr. Adairs A. *Old Method of Buying Straw*—Prior to 1946, our mill purchased straw from a broker who, in turn, purchased it from the farmer or balerman. There were no direct contacts with the mill and the farmer. If the farmer had any complaints or problems he had no one to contact but the broker. If the broker thought the farmer had a complaint worth while he, in turn, would take it up with the mill executives, and they, in turn, would take it up with heads of the various departments. So by the time the complaint got to the right place it was so tangled up and rearranged from all the retellings, that in most cases it was dropped completely and the farmer would give up in despair.

We do not blame the broker for this condition, because it was practically impossible for him to know what was going on at the mill since he actually operated his business some six to eight miles from the receiving yard.

We feel sure that in buying straw through the brokerage method that the person-to-person relationship that should exist is never established. In other words, the mill just knows the broker and he never gets to know the man that is actually producing the straw.

After all, a bale of straw produced by one man is as different as day is from night, as that produced by another. To me it denotes whether a man is a good farmer or a bad one. You can look at a clean, dry, and tight bale of straw, and 9 times out of 10 that will indicate the type of individual you are dealing with—good, clean, thrifty type.

B. *New Method of Buying Straw.*—Since the establishment of the Straw Division within the Alton Boxboard in 1946, we have developed the personal contact system to the highest point in the company's history. We maintain an office about two blocks away from the mill, at which point we have all straw trucks stop for inspection; here they receive their tally and weight ticket which they take to the scale and also to the yard inspector. After unloading and weighing out, the trucker again stops at our office to receive his settlement sheet.

By this method we have two checks on a load of straw—our inspectors in our office, and a check from the yardman either at our chain or in the yard.

During the past two years we have had very few complaints on moisture and weed dockage. We feel this is due to our Delmhorst Moisture Tester, good inspection both in our office and in the yard, and also due to our fieldmen being constantly in the field and knowing the balerman and the job he is doing.

The past year we have purchased all types of baling equipment and resold it to our balermen. This equipment consisted of balers, rakes, mowers, tractors, and trucks.

We also carry a large supply of baling wire of all kinds. All of these items are purchased by us and resold to balermen and farmers at cost plus a small handling fee.

In our field-ricking program we have some very interesting figures. Our ricking program has increased in tonnage and in balermen in the past two years. In 1946, our tonnage in field ricks was 1750 tons contracted for by 3 balermen. In 1947, our tonnage in field ricks was 10,722 tons contracted for by 71 balermen. In 1948, our field-ricking program ended with 16,558 tons contracted for by 121 balermen. In other words, our average tonnage per balerman has decreased from 585 tons in 1946 to 136 tons per balerman in 1948.

We intend to continue our ricking program next year and expect to increase our balermen which, in turn, will cut down the tonnage per man. We feel by using this plan our over-all straw buying plan will be held at a more even keel, even after the loss of several balermen, which in reality boils down to the saying "Don't put all your eggs in one basket."

C. *Our Plans for the Future*—When the Straw Division of Alton Boxboard was formed we were faced with three big questions:

1. Where can we buy some straw right now?
2. Where can we get enough machinery to do this job?
3. How far do we have to go to get the straw we need for our operation?

We solved the first question by going to the Dakotas for an immediate supply and since that time we feel that we have and will be able to take care of this situation within our own state.

We answered the second question by finding quite a bit of machinery and selling it to the balermen. We feel that the implement dealers will work with us if we work with them, and it will not be long until our machinery problem will be solved.

The third question is the one we are working on right now. In the picture that we will show you sometime today, you will note that we have 8 counties within 75 miles of our mill and in these counties we have 377,600 acres of wheat grown. If we could procure 15% of this acreage we would have ample straw for our operation.

So we intend to carry on an educational program with our farmers in our local counties. We shall show them the new types of equipment being used to step up their baling operation, and convince them they can grow better clover by removing straw from the fields, by showing them actual examples. We feel that we can attract many more people by moving pictures than we could ever hope to by talking or by mailing them literature to read.

Dr. Lathrop: Thank you, Mr. Adair. That was a very practical paper. The second paper on this panel is "A Farmer's Market for Straw" by J. A. Belford of Ball Brothers Co., Muncie, Ind.

Mr. Belford: Since the general use of combines in harvesting grain, the necessity of acquiring and collecting the bulk of straw required by strawboard manufacturers for the year's consumption within a very limited time has brought about problems in the procurement of this commodity not existing prior to 1940.

In those days, when the old-fashioned, and now nearly obsolete, method of threshing was general, it was possible to have year-round operation of balers of the stationary type working at stacks of straw blown directly from the separator. By this method the straw was available in large quantities in the spring, after it had served the purpose of protection for the farmer's livestock from winter weather, and afforded a saving of much feed, which otherwise would have been required by the stock. Mills were not required to carry large inventories in storage yards, as straw could be baled in the spring to meet any deficiencies in supply to carry through to the next harvest.

Now, since the changed conditions, total storage must be greatly increased to assure ourselves of our requirements for approximately nine months of the year for we do not have the carry-over on the farms available as in the past.

Following the advent of combines, which were purchased by farmers as fast as they were produced, there was a marked scarcity of pickup balers as production in that line lagged far behind combines, and as a result only a small percentage of straw was reclaimed after combining. This situation caused a scarcity of straw, and its price pyramided to high levels in spite of the fact that there were millions of tons as a potential supply for strawboards, and this lack of a sufficient number of pickup balers brought about a highly competitive market for the small quantity of straw reclaimed under existing conditions.

The production of pickup balers in the past few years has relieved the situation somewhat, but when we consider the short period of time in which good quality straw can be reclaimed, the supply of balers of this type is far from being adequate. Straw must, of necessity, be baled promptly after combining to avoid deterioration, and the inclusion of weeds

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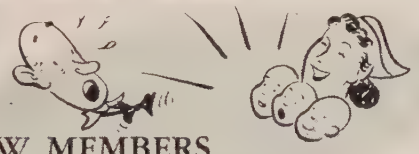

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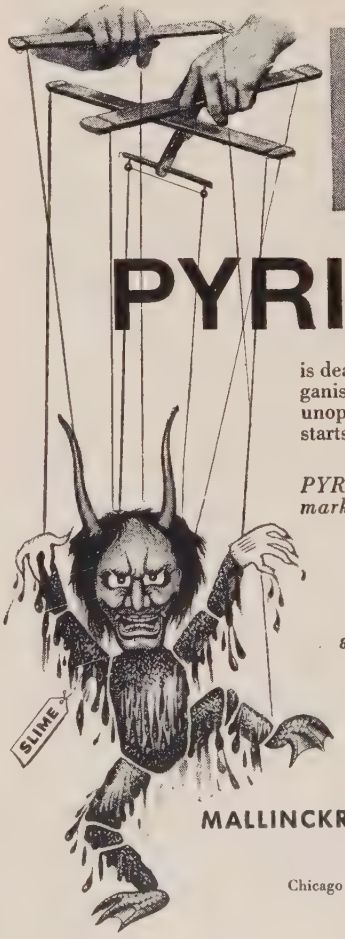

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with the straw. Weeds spring up in stubble alarmingly fast.

We are all interested in doing something about the prevailing high prices we are forced to pay for straw delivered to our mills, and nothing much can be accomplished along this line until the quantity of straw available exceeds the demand for same.

Transportation of straw from farm to mill is one contributing factor in high costs. Low-weight bales affecting transportation tonnage revenue, the increased price of trucks, gasoline, repairs, insurance, and labor do not afford much hope for reduction of costs in that line. Rail rates at present and the threat of still higher tariffs make shipments of large quantities of straw by that means less desirable.

The prevailing high prices for pickup balers is another factor to be considered. Original investment in modern balers, running nearly four times that of the old stationary balers, require higher prices for custom baling, and if purchased by the farmer, unless he has large acreage of hay and straw, necessitates a high price for his straw baled for sale. Since all other farm produce is bringing a high price, the farmer wants his straw to bring a comparable return.

How then in the face of these facts can we possibly bring the price of straw down below present levels?

May we suggest consideration of the following operation as a possible saving, independent of the causes of high prices mentioned above.

One problem the mills have to face as a result of present conditions is the necessity of storage of straw in outlying areas, due to inability to store all the available supply in the mill yards in the short period of time required, since facilities at most mills are inadequate to handle larger quantities.

Lack of storage space, shortage of labor, congestion of transportation and objections by truckers to delays in unloading are some of the difficulties encountered.

Too much straw in small quantities is left in the fields where baled, due to inability of balermen's trucks to keep up with the balers. This results in loss from exposure to rain and sun; much breakage of bales so exposed follows when moved from temporary piles.

Farmers object to removal of straw across fields which may be cut up by trucks, tractors, and trailers when the ground is soft, thus delaying removal of the straw, and increasing loss from exposure. We believe it is within the province of the mills to reduce such losses. May we refer to the paper read by V. E. Bush, of Hinde & Dauch, at the meeting held in Peoria, Jan. 13, 1947, in which he made the following statement: "Straw is a commodity that is very hard to buy or sell. It is necessary to go to the farm to buy it. The need of the establishment of a straw market is suggested." Ball Brothers Co., had anticipated the action proposed by Mr. Bush by several years, and during 1945 and 1946 had made a modest beginning in the establishment of straw markets, and in the succeeding years of 1947 and 1948 we have been developing the idea, and have been able to acquire considerable straw for delivery as needed over a period of six months following harvest, with a minimum of loss from breakage and deterioration of quality.

Through cooperation with shippers who have fleets of trucks, and who want a year-round revenue from them, scales were installed by these shippers at their places of business, and straw was purchased directly from farmers upon delivery by them to their scales, for weighing and grading, and then taken by the farmer to the nearby stacking point for unloading at the conveyor.

The stacks were built according to our specifications, and of sufficient height to allow a minimum percentage of bales exposed to the weather. Farmers were paid by the shipper on his own grading. No liability is assumed by our company for loss caused by poor judgment or insufficient dockage in his grading of the farmer's straw. This system appealed to the farmers, as it is the same procedure used by them for years in disposing of grain to elevators. Surprisingly large deliveries were made daily.

One interesting development of this operation was the expression of pleasure and satisfaction by farmers, that they were thus able to move the straw from their farms promptly with a minimum of exposure to weather, and also to have their fields cleared for fall plowing, if desired, immediately following baling of the straw.

We found by this operation that a much larger percentage of straw within a reasonable radius of the stacking point could be acquired, without using the shipper's trucks in collecting it from the various farms, as most farmers have adequate means of transportation for moving their own straw.

All types of transportation from horse-drawn wagons, family cars with trailers, tractors, and trailers to farm trucks were used to bring their straw to the market.

Establishment of this market did away with the solicitation by the buyer, thus saving time and travel in making visits to the various farms to deal for the straw as mentioned by Mr. Bush. It is our belief that the development of this idea may lead to more efficient methods of acquiring straw, at a lower cost. As the method progresses and is enlarged by establishing such markets by mills at strategic points, without causing too much competition, the straw instead of being purchased on a seller's market may switch over to a buyer's market, which is something to be greatly desired, and a welcome change from present conditions.

DR. LATHROP: Thank you, Mr. Belford. The next paper "The Effect of Educational Campaign on the Availability and Condition of Straw" will be read by H. Lyon of the Terre Haute Paper Co., Terre Haute, Ind.

MR. LYON: Since 1945 the Terre Haute Paper Co. has been carrying on an intensive and extensive program to obtain straw closer to the mill and also a better quality of straw.

Our first step in trying to improve the quality of straw was to find some method of getting an accurate test of the moisture content in damp or wet straw. We wrote a number of manufacturing concerns who had made moisture testing equipment for testing moisture in lumber, paper, and grains, but no company had any equipment available for testing moisture in straw. After explaining the instrument we had in mind and the nature of the product to be tested, the R. S. Hart Co., of Jersey City, N. J., made us an instrument that worked fairly accurately but required a certain amount of calculating which took time and gave chance for error with an inexperienced operator; however, this instrument was used during the 1945 season with good results.

Early in 1946, Mr. Delmhorst, of the Delmhorst Instrument Co., Boonville, N. J., perfected a moisture tester with an indicator that anyone could read and determine the moisture content of the straw at a glance. We ordered a Delmhorst instrument and used it at one of our mills, using the Hart machine at the other mill. In October of 1947, Mr. Delmhorst informed us he had made various improvements on his tester and we purchased two of the new instruments, one for each of our mills, and have been using these instruments since, with good results.

Since we had no accurate method for docking for moisture prior to using the testers, some of the shippers were somewhat bitter at first about accepting the readings on the moisture testers. However, by drying bales for them and checking dry bales and bales they knew were wet, and by using every persuasive and educational method we could think of, we have overcome, to a great extent, the prejudice against these moisture testers. We now have very few complaints from the shippers.

After using the moisture testers, we have found that our shippers make a greater effort to keep their straw dry and haul it to the mill or rick it sooner after baling than they formerly did. We feel these instruments have saved us from buying many tons of water.

Prior to the combine method of harvesting wheat, it was a rather simple procedure to obtain enough straw from a few shippers within a reasonable distance of the mill to keep the mill going. These men baled straw the year round from stacks that had been threshed. Our company had possibly 25 to 30 of these men baling straw and each man was given a certain territory and all straw coming from that territory had to be sold through this particular man. After introduction of the combine, we found it advantageous to increase our number of shippers because of the short season combine straw was available. This made it necessary to do away with the territorial method and to take straw from anyone having straw to sell. Since straw originates on the farm, the proper person to buy straw from was the farmer. In order to get straw from the farmer, it was necessary to inform him there was a market

for his straw and the paper mill would rather purchase it direct than through a jobber or commission man.

The only way we could get the message to the farmer that we would buy his straw was by personal contact, by the medium of advertising in newspapers and farm magazines, through the use of the radio, and by direct letters to the farmers.

During the past three years we have kept a continuous ad in one of the leading Indiana monthly farm magazines. This ad is two columns wide and about one-third of the page in length. The contents of the ad states that we buy wheat or rye straw the year round in any amount. This ad has brought us as high as 100 inquiries after a single issue, and no issue is published without getting some inquiries.

Just before harvest begins and during harvest, we run a 1- to 2-inch ad in the classified section of at least 6 newspapers in towns within a radius of 85 miles of our mills. The ads are inexpensive and have produced results, since most farmers make a habit of reading the classified section of their papers.

All farmers have radios and they listen to the livestock market reports, farm programs, and newscasts. During the past two harvest seasons we have purchased time for spot announcements from our local radio station each day just before or after one of the above-mentioned programs. In these announcements we told the farmer there was a market for his straw, the price, kind used, and reasons why he should sell his straw, and so forth. This advertising was used during July and August. Such advertising accounted for a large amount of local inexpensive straw being brought in that would otherwise have been wasted.

Our company tries constantly, as does every other company, to build and maintain the good will of our shippers. Prior to the war, we gave each shipper a gift at Christmas. The increasing number of shippers recently, however, forced us to discontinue this practice. We have substituted small, inexpensive advertising items such as pencils and key chains which are enclosed in letters and cards sent out periodically to shippers.

One of these letters is sent right after the harvest and stacking season is over and is in the form of an appreciation letter. We send a letter about the first of June reminding shippers we will buy straw again this year, suggesting that they get their equipment ready for baling, informing them about wire, and giving any other information that we have. In this particular letter the shipper is always informed that we cannot use weedy straw or round bales. Next harvest we plan to incorporate in this letter the fact that we can no longer use oat straw.

At the entrance to each of our mills there is a large sign stating that only clean, dry wheat or rye straw, free from weeds or clover, is suitable for papermaking. Words to this same effect are printed on each settlement sheet, along with the statement that weedy straw will be rejected.

Our mill does reject weedy straw and even though it has caused some ill feeling, we feel it has paid well for us not to use straw that will slow our machines or cause us to make an inferior product. Since September 1, our graders have turned down 18 cars of combine straw due to excess weeds. The shipper was contacted in each case with the offer to return the straw, but no one has wanted it back, and the straw has been disposed of for bedding or mulching road shoulder, grass seedings, and in some instances sent to the dump. In many cases the sale of the straw did not pay the freight. When trucked straw is rejected, the hauler either hauls it home or hauls it to our dump. We realize this is a harsh method of bettering the quality of our straw, but it is the only way we have been able to make our shippers know we cannot use or take weedy straw.

During the year 1945 we received straw from 443 individual straw shippers. In 1946 this number was increased to 558. In 1947, we had 776 different shippers and in 1948, so far we have received straw from 839 different persons. We just completed a check on the new people shipping in 1948 and found that there were 425 new names on the list shipping in 1948 who had not shipped in 1947, making 1264 different individuals who had shipped straw during the past two harvests. During the past harvest and stacking season, we unloaded as high as 288 truckloads of straw in one day in addition to some car straw, and we did not receive straw to stack after 4 p.m.

Along with our periodic letters, we have enclosed leaflets and pamphlets such as the papers prepared by Dr. Willard of the Ohio State Agriculture Experiment Station, explaining the effect of combine straw on new seedings and the booklets on "Straw Injures Your Legume Seedings." Other mimeographed sheets have been sent out such as the "Do's and Don'ts" for balermen and the "Ideal Specifications for Baled Straw" as furnished by the Northern Regional Research Laboratory.

In 1946, we received 74% of our straw from within trucking distance of our mill, and in 1947 about 85%. This year, from all indications, we will get 100% of our straw within trucking distance of our mill.

We plan to continue our educational and advertising program an endeavor to get all our straw closer to the mill, which will mean cheaper straw of a better quality.

Dr. Lathrop: Thank you, Mr. Lyon. We are glad to see that this educational program is making some real headway. The next paper by A. R. Miesen of the Northern Pacific Railway of St. Paul, Minn., covers a discussion of something in the future. There is a large industrial development taking place in North Dakota and Mr. Miesen will talk about "Straw Supply and Water Development in North Dakota."

Mr. Miesen: The North Dakota small grain acreage in 1948 totaled 16.3 million acres of which 9.6 million acres were wheat, 0.4 million rye, 2.2. million oats, 2.6 million barley, and 1.5 million acres of flax. These acreages vary some from year to year but not materially. The yield of straw will be near a half ton per acre, but since the use of the swather and combine have come into the picture, less and less straw is available for baling. High grain prices, good crops, general prosperity, labor shortages, difficulty of gathering straw and low straw returns have not made straw salvage attractive to the farmer. Increased baling equipment may be part of the answer, but until the farmer can expect an outlet for a quantity of straw annually at a fair price above the fertilizer or soil building value, he will not be interested much in a straw salvage program in North Dakota.

In the past, North Dakota has been short of commercial water but a tremendous water and power development program has now been initiated. Since this water and power development is in the center of the straw-producing territory, why would not processing or plant location in North Dakota be worth some consideration. Collection or assembling cost would be materially reduced. I asked Dr. Aronovsky if I might say a few words about future water development in North Dakota. I quote from Governor Fred B. Aandahl, Bismarck, North Dakota:

"It is doubtful if very many people realize the magnitude, size, and importance of water development projects that are now underway or contemplated in North Dakota. We are in the heart of the vast Missouri Basin Development program In harmony with what is being done in the Missouri Basin, there are coordinated projects in the valley of the Red River and its tributaries in eastern North Dakota.

"Under construction at the present time is the Garrison dam, some 70 miles northwest of Bismarck; the Heart Butte dam; the Bald Hill dam north of Valley City and the Park River dam. There are several other dams that we can reasonably expect will be built soon.

"From all the reservoirs created by dams located in the western two-thirds of the state, we can anticipate the use of large amounts of water for irrigation purposes. Those located in the eastern one-third of the state are intended primarily for flood control, and as a source of municipal and industrial water. These projects are all being constructed with Federal funds. It is estimated that the Garrison dam will cost about $170,000,000 and the Missouri-Souris irrigation and diversion project will cost about $212,000,000. Other dams mentioned will cost from two to eight million dollars. The Federal government is anticipating an expenditure of close to half a billion dollars in water development in North Dakota. The work is now well underway.

"Let us turn our attention to the benefits that will come to North Dakota. Listed in the order of their importance they are irrigation, hydroelectric power, adequate municipal water supply and flood control. Irrigation is of first importance

Out of all these potentials and other small projects, we anticipate the irrigation of one and a half million acres. We cannot anticipate that on the big projects of the Missouri-Souris or Garrison reservoir that water will be available to the land in less than ten or twelve years. If we can then develop the land and place it under irrigation at the rate of thirty thousand acres a year it will take an additional fifty years to complete the projects. In terms of the proposed plans it will irrigate approximately 10% of the crop land of North Dakota. With the growing of specialized crops and particularly winter feed for livestock, it will have a far-reaching and stabilizing influence upon the agriculture of the state. It, of course, will increase production and give employment to a larger population.

"Second in importance is the development of hydroelectric power. The Garrison dam will have the power to develop 329,000 kilowatts of electric energy. This has been estimated at two or three times as much as the total amount of electrical energy used in this state at the present time.

"Of third importance is an adequate supply of municipal water. Much development that rightly belongs to our state, particularly in the processing of agricultural produce has been stifled by the absence of an adequate source of municipal water. The dams that are being built and the others that are proposed will do much to solve the municipal water problem in North Dakota.

"Fourth in importance is the benefit of flood control. For those who live in the limited areas of the state that are affected by floods it is a paramount benefit. In all but the flat land of the Red River Valley in the east the solution seems to be reasonably complete. In the Red River Valley the problem is more severe. A stupendous development program is under way in North Dakota."

So much attention has been centered on the Garrison dam that the lesser but still important other dams which will come into being are being overlooked. These are Bald Hill, Sheyenne, and Jamestown.

The first of the dams to impound water in 1949 will be the Bald Hill dam on the Sheyenne river, 16 miles north of Valley City, now under construction. The lake above the Bald Hill dam will be a little gem of clear blue water. It will average half a mile wide, 41 miles long, and will be 60 feet deep at the dam. It will nestle in the hills, which slope downward sharply to the valley floor and, since the Sheyenne is not a silt-laden stream, the water will be clear. The reservoir storage capacity to normal full pool will be 70,700 acre feet or at 326,000 gallons per acre foot, a total of 23 billion gallons covering 5430 acres. This 41-mile-long man-made lake is in the heart of the straw-producing area in eastern North Dakota, and only a short distance from large supplies of lignite coal. It is adjacent to Valley City, an aggressive and progressive town of 6000 served by two main line railroads.

As Governor Aandahl of North Dakota said "A stupendous program of development is under way in North Dakota." We who serve that territory will be happy to be of assistance, if you wish to investigate raw straw supplies for shipment, or for processing straw in the producing area.

The last paper on the panel is by Wisman of Central Fibre Products Co., Quincy, Ill., entitled "Development in Straw Collection and Baling Equipment and Methods."

Mr. Wisman: Since 1940, we have been "playing" with pickup balers. We could not help but feel that our biggest problem was straw collection. Along with the development of baling equipment we are very much interested in cost. We believe that the one-man baler is a solution to our problem. It has caused us headaches; we have had a lot of bad experience and we have had good experience. In view of the fact that some of it was reviewed here in the last year or two, I am going to start with what we have done in the last several months.

In an effort to endeavor to remove the remaining "bugs" in the automatic wire-tying baler, with which we have been working for the past two years, we took a stock machine and more or less rebuilt it and strengthened it according to our ideas of what was required. This machine was rewelded and somewhat reinforced. We also put a larger motor on this baler in an endeavor to secure a bale of straw between 70 and 80 pounds.

After this baler had been operated in the field, additional changes were made to improve on the feeding capacity. These latter changes now appear to have the possibility of not only bringing increased production, but also produce the best formed bale that has yet been put out by an automatic machine, the bale being uniformly formed.

This machine was viewed in operation by the Assistant Chief Engineer of the company who manufactured the original machine, and in his opinion was the best machine that he had seen in operation.

Since this machine was placed in operation the various points of reconstruction have been discussed with the manufacturer and it now appears that it will be put out as a stock model sometime within the year 1949. There will probably be some little additional charge due to the fact that it will be necessary to use additional weight in the machine, and as explained earlier, a larger motor. This additional cost, however, would be insignificant when compared with the greater production possibilities and also considering the fact that it would be able to produce the type of bale desired by the strawboard industry.

During the past year we received delivery on 70 automatic wire-tying machines and we, of course, had a great deal of varied experience. We have come to the conclusion that our biggest problem is educating the operators in the efficient operation of this type machine. We also have taken up with the manufacturer's Service Department, the matter of better dealer service.

With the full cooperation of everyone concerned, all the way from the manufacturer down to the dealer's organization, and including the operators, we feel that the only remaining obstacle to the production of reasonably priced baled straw will be weather conditions. This latter hazard may have some possibilities of being offset somewhat, should the use of 2-4-D come into popular usage.

Dr. Lathrop: I think you gentlemen will agree with me that this has been a very practical set of papers. We will now have the movie "Bringing in the Sheaves," prepared by the Alton Co. (Showing of Film).

Mr. Adair: A lot of folks have asked me "Why show moving pictures—why don't you just write a pamphlet and give it to the farmer? This is no reflection on the pamphlet, but we believe sincerely in moving pictures. A man will sit down and look at a moving picture, but if you just hand him some literature, he very seldom reads it. We think that we can sell our program at least 80% by the eye. This is the first time this picture has been shown in public and I would like everyone to comment on it—we want criticism.

Dr. Lathrop: I feel quite sure that Mr. Adair will appreciate comments from you men with regard to his film. It seems to me that this is one of the most educational films I have seen, because it shows some of the things that should not be done as well as some of the things that should. I will now open the meeting for discussion.

Mr. Woodford (*Kansas Industrial Development Co.*): Mr. Adair, as a stranger here among you for the first time I want to say that your film was very revealing to me because our state covers a lot of acreage. We have plenty of straw, but I never realized just what the problems were. This film is certainly a swell job. I should think that you fellows who are in this business should feel that it has pretty well covered all the answers.

Mr. Adair: Thank you. Please feel free to criticize the film since this is the first public showing. We have been cutting it up and putting it together for four months.

Mr. Burns (*Terre Haute Paper Co.*): Mr. Adair, to whom do you expect to show this film?

Mr. Adair: We are going to operate through the Farm Bureau advisors in the 8 counties that were indicated in the film. We are going to show this in some 40 places in the next five months, mostly to small groups of 30 to 40 men. We know that it is hard to tell a farmer anything, but if we can show him this picture and he will ask questions, we have the problem solved.

Mr. Bush (*Hinde & Dauch Paper Co.*): Do you generally carry insurance on straw that is stacked in the field?

Mr. Adair: If a rick has 2500 bales or more or if it is piled close to something that, in the buyer's opinion, is a hazard we

place the insurance with a common carrier. Otherwise, we carry our own insurance. We take any loss not covered by insurance because we make advances on all this straw. The ricking program at Alton works like this: When a man has his rick completed, he calls our office and we inspect his straw. The weight is established at the time when it is bought. Then when he brings his straw in, some two or three months later, he knows exactly what he is going to get. We come to an agreement at the time of baling, when the straw is dry, and we have had no trouble in the past two years.

MR. KRANCHER (*Ball Brothers Co.*): Mr. Adair, do you weigh the straw in field ricking before it is ricked?

MR. ADAIR: I would say we weigh about 10% of the rick, and get an over-all average of the weight of bales in that rick. We try to get out there ourselves. We have told our balers, in case of rain, to try and get 10 to 20 bales in the barn where we can actually weigh them to determine dry weight then and there. That is what we pay for. In that way we eliminate all the moisture screening and everything else that goes with it until the straw is actually delivered.

MR. BLANDIN (*Central Fibre Products Co.*): Are those bales and ricks of straw all from one farmer? Does he fill his own rick, or do several feed into one rick? If so, how do you determine the weight on those?

MR. ADAIR: Well, in most cases they are one farmer's, but we do have ricks where there are more than one farmer feeding into a rick. We try to have the one farmer determine the weight when the other farmer brings in his bales.

MR. LANNAN (*Central Fibre Products Co.*): I would like to remark about insurance. I do not know what the experience of other companies has been, but so far I do not believe Central Fibre has lost any ricks of straw that they had in the country. The first year or two we insured with our regular insurance company. We found this rather difficult and quite expensive, so we set up a plan in our organization of carrying our own insurance, and for two years we have gotten by very well. We set out in a separate fund as much money for insurance as it would cost us at regular insurance rates, and this fund built up over a period of three or four years. Soon we are going to be in the clear and take care of our own insurance. This seems much easier than it is to try and place the insurance through so many different companies and in so many different states.

MR. ADAIR: I might add that we have carried our own insurance on ricks smaller than 2500 tons in the past three years, and our total loss for that period was $370, which is a very small amount when we are talking about some 30 to 50 thousand tons of straw.

MR. BUSH: In your stacking program do you pay for this straw as it is delivered to your yards in various places?

MR. ADAIR: No, Mr. Bush. Any straw that we advance on is run over regular wagon scales and then an inspection is made. If the delivery price is $15, we advance $10. We do not assume any obligation to pay the man any loss he has on the straw. He has to anticipate what our grading will be. It has worked out very well so far. There is, however, a provision where there are broken bales; where it does not pay to rebale them, we make an allowance for the amount of money that the man has in those particular bales. It is much cheaper to do that than to rebale and haul them that distance to the mill.

MR. BUSH: Do you have conveyors?

MR. ADAIR: We furnish conveyors. We found out that we could buy them cheaply enough and as their actual life is usually 20 to 30 years, it is a very cheap investment.

MR. KLEPFER (*Fort Wayne Corrugated Paper Co.*): Mr. Adair, you spoke of taking the weight of the rick that you advance upon. Do you take those weights after the rick is constructed or during the process of construction?

MR. ADAIR: We try to take it during construction, but a lot depends on when the straw is being harvested. You know we just cannot get to all the fields during baling time.

DR. ARONOVSKY: Has the moisture tester worked out pretty well, and do the farmers accept the value indicated by the instrument?

MR. WISMAN: Speaking for our company, I would say they do. In fact, I think it is the nicest thing that has been developed for determining moisture in straw. I can illustrate with one case. One evening during stacking season, a man came in the yard with a trailer load of straw. As he was unloading the rick he said: "The man at the rick tested my straw and it tested about 30 or 35% moisture. I know that straw is not that wet." I said: "Just leave 3 bales on the truck and I will stop and test them." I tested the bales and, if I remember correctly, 2 of the bales tested 22 to 38%. "Oh," he said, "they're not that wet." So we opened the bale and they were just as damp as could be inside. If a man does not take your word for it, just break the bale open and 9 times out of 10 you will find that you have the indicated moisture in that straw. We have had very few complaints about the moisture tester.

MR. BURNS: When you rick outside you use the conveyor to put up your ricks. How do you de-rick them? How do you get the straw down and on your truck?

MR. BELFORD: The bales are usually dropped down onto the truck. We have the stacks arranged so that as they are being taken down they vary in height; the truck coming in can have the bales dropped on it first from the lowest point and then from the adjoining stack which is a little higher. None of the drops should be so long as to result in a large number of broken bales.

MR. KRANCHER: Mr. Wisman, you spoke about the pickup baler you had rebuilt and mentioned the fact that you have produced a heavier bale. How much heavier?

MR. WISMAN: The bales averaged 71 pounds, and we had the so-called automatic spring tension on that baler. I think we can get up to about 80 pounds. Our bale weight average at Quincy has been about 67 pounds. What it will be this year I do not know; we are getting better baling and we hope to continue to improve. We make a 16- by 18-inch bale. 45 inches long. The reason I am partial to the longer bales is that you are using your whole tying mechanism less by using the 45-inch than the 42-inch bale. You also save wire because for every 3 inches of bale you gain, you cut down the number of ties necessary.

MR. BURNS (*Terre Haute Paper Co.*): Are you buying baling equipment for people who bale for you, and are you financing it for them?

MR. WISMAN: In the past, we have rented out baling equipment—not a very good arrangement. We have some very good operators, where the rent has more than paid the depreciation and maintenance. But our preferable method is, frankly, to get as much cash out of the operator as we can. In most cases, this year we put out balers on the basis of either getting the whole in cash or a $1000 down payment and giving the operator 12 months on the balance. In other words, we have tried to get the equipment, tractors, rakes, or balers for the man who is operating for us without his having to pay black market prices. We feel that this builds up good will. We now have the experience with the 70 balers we had this year. If we can get this straw closer to the mill, the financing will well take care of itself. If you get $1000 down on a baler and you have a good operator, you are not taking much risk. The machine can be a year old and you can still get your money out of it.

MR. ADAIR: We at Alton have bought the baling equipment directly from the manufacturer in some cases, and in other cases, from the dealer and, in turn, we put our equipment out much the same as Mr. Wisman. We like to get a third down and the balance over two baling seasons.

DR. LATHROP: Mr. Bush, haven't you had some experience in connection with purchasing balers, or renting them?

MR. BUSH: We have rented out some balers. In a number of cases we have collected more rent than the balers cost us. That does not always happen. We have had some operators who have had some misfortune this year, particularly with the automatic-tie baler. Not everybody can run these balers. We had one man who baled 159 tons of straw, and we had a repair bill of about $250 to put the machine back into operation again. We sell for exact cost and cash only; we make no guarantees and no profits, but we will render assistance to the shipper and get him into operation if he gets into difficulty.

MR. BURNS: What is the approximate average radius in which you got straw this year?

MR. WISMAN: We have had to go into South Dakota for some of our straws, and have gone as far as 700 miles. The

majority of our straw comes from within 200 miles.

MR. ADAIR: About 125 miles, and we are trying to draw in closer than that.

MR. BELFORD: Our trucking radius is about 146 miles, but, unfortunately, we are in a location where we are in competition with other mills and that does not allow us much leeway in certain directions. We get straw in cars from Wisconsin and from Southern Illinois. All the rest of it is trucked in.

MR. LYON: We get 95% of our straw within 150 miles of our mill, all of which is trucked in; the other 5% will come from within 200 miles this year.

MR. GOETZ *(River Rasin Paper Co.)*: Our extreme radius is from 125 to 150 miles. I would say that 75% of our straw comes from within 75 miles.

DR. LATHROP: Would that be true also of Consolidated Paper Co.?

MR. GOETZ: I would think it would be, but, of course, we draw some straw out of Canada, within 130 or 140 miles of the plant.

MR. OWEN *(Hinde and Dauch Paper Co.)*: In Ohio, I think our situation is very close to that of River Raisin, a maximum radius of about 125 miles, all trucked in. In a normal season, of course, a major portion comes from a smaller radius. As far as Fort Madison is concerned, the story is a little different. It is trucked in from so-called local areas, but we also have to go out to South Dakota and Nebraska.

DR. LATHROP: Dr. Johnston, do you know what your radius is?

DR. JOHNSTON *(Waldorf Paper Products Co.)*: No. We get our straw from North and South Dakota and from western Minnesota.

DR. LATHROP: Mr. Dunlop, what is your experience in eastern Ohio?

MR. DUNLOP *(Ohio Straw Co.)*: I think we have an overall average radius of approximately 100 miles. The greater percentage of our straw comes in at an average radius of around 65 miles, but we do draw some straw from Pennsylvania and West Virginia.

DR. LATHROP: What is the experience up in Canada?

MR. PALM *(Hinde and Dauch Paper Co. of Canada, Ltd.)*: We have quite a different condition up there. We have not as yet got anything like the extensive mechanization of farm operation in the areas from which we draw our straw which you have down here. The consequence is that a lot of the straw is still blown into stacks. In fact, I venture to say about 70% of the straw we get is actually stack straw. We operate approximately 15 to 20 balers throughout the open season of the year ourselves. They are our property, and our men operate them, and the straw is trucked back to the mill by arrangement with certain local truckers. The remainder comes in by cars, and it is baled by local people in the immediate area from which the straw is shipped. Our average radius from our own balers is about 50 miles from the vicinity of the mill. The remainder comes from up to about 250 miles.

DR. ARONOVSKY: Mr. Olson, can you tell us something about your experience in the Dakotas and Minnesota with 2-4-D on flax and wheat fields?

MR. OLSON *(Archer-Daniels-Midland)*: This is the first year 2-4-D was used extensively. The results have varied quite a bit, and nobody knows yet whether it is going to be a permanent thing. Up our way they are talking more about controlling weeds through agricultural practices rather than with 2-4-D. The operators do not all seem to know how to apply 2-4-D correctly. They have had good results with 2-4-D in our territory, mainly in the Red River Valley.

MR. SHEW *(Ball Brothers Co.)*: Mr. Miesen, according to your paper, you have plenty of water, straw, and flour in North Dakota. Is the coal developed?

MR. MIESEN: Yes.

MR. SHEW: What would be the possible stream pollution problem?

MR. MIESEN: I believe that the dam that is being put in north of Valley City at the present time, and the same thing will apply to the dams at Jamestown and other points, will be of help to the stream pollution problem. I might say, in addition, relative to 2-4-D that everybody is very much interested. The price of flax will determine the number of acres planted to it, but people in North Dakota and Montana, in the Red Valley, and on the Minnesota side, have definitely gone to the use of 2-4-D, using airplanes where possible. They have had some bad results. Some people have had to pay for a section or two of potatoes, as a result of the use of 2-4-D, but I think they are going to use ground machinery more than they have in the past. Minnesota has already inaugurated a scheme whereby every airplane operator must be licensed and will be responsible for damage to a neighbor's crop when he dusts or sprays. We have been very surprised at the way people have taken hold of 2-4-D, and we think it is primarily because the price of grain has been good. They know that weeds use moisture. We are very close to the border now, so far as the amount of moisture necessary to produce a good crop is concerned, and it is the inhibiting factor in that territory. Mustard grass spreads very readily and grows just as thick as hair on a dog's back in the Red River Valley and in the territory 100 miles west, adjacent to the Red River Valley. If you spray the small grain when around 6 to 8 inches high, and do a good job at that time, you can practically eliminate all of these weeds. 2-4-D is going to be used very extensively unless we have a setback of some kind. We still do not know what residual effect it is going to have. We have had some bad reports on 2-4-D, and also on DDT where it has been used very heavily on potatoes and sugar beets. I think some of these effects must be determined before we can find out how extensively 2-4-D will be used.

DR. LATHROP: Gentlemen, I want to thank the members of the panel for their excellent papers and all of you for the excellent discussion.

DR. ARONOVSKY: We had a nice and profitable session this morning on straw procurement. The panel this afternoon will be on "Straw Pulping and Refining." The first speaker on our program this afternoon is V. E. Bush, Manager of the Hinde & Dauch Paper Co., Fort Madison, Ia., who will talk on "Some Practical Aspects of Straw Pulping."

MR. BUSH: Dr. Aronovsky and gentlemen. I have on several occasions spoken in public, but I believe that this is the first time that I have had to talk to a group that knows more about the subject than I do. I have been in the paper manufacturing business just long enough to realize how little I know about it. There are times when the mill is running along in good shape and producing good paper and lots of it, and we think we know all the answers. Then all of a sudden something happens and we begin to realize that we do not know too much about it. Our operation is nontechnical and is done by practical men who have had years of experience. They know by sight and feel when the results they want are achieved, and they also know how to get those results. All the equipment we have for testing and control is an oven for drying the samples, to get a moisture test, a scale for getting the weight, and a crush tester. When we get all through this is the product we come out with (sample strawboard sheets). This is an indication of what can be done handicapped as we are with only very little technical assistance. We do have a technical director at our Sandusky office who gives us instructions based on technical information. Aside from that we just do not have any at the plant. So, for my part of this talk, I think I can do little more than to tell you how we operate. Maybe all of you do the same thing. I doubt it, because no two do things just alike. I do not think there will be anything new in what I have to say, but if there is, you can accept it for what it is worth.

We grade and weigh our straw when it comes into the plant in very much the same way as all of you do, except that we do not have any instrument for checking moisture. When this straw goes into the rotary, it is again weighed and graded in exactly the same manner as when it is received from the shipper. In order to get uniformity of stock, we feel that it is just as important to measure the straw as it is to measure the chemicals.

We put 10,000 pounds of straw, dry basis, into each rotary. We have no predetermined number of fills, using whatever number of fills is required to put that much straw in the rotary. The first thing we put in the rotary is 12 tons of water, then dry straw, followed by the lime. Then we start cooking our first fill, followed by the second and the third, until the rotary is completely filled. Then the remainder of the chemicals is added. We do not operate our rotaries on a continuous schedule. We have two cycles during the 24-

hour period, the day shift and the night shift. All the rotaries are brought up to pressure at the same time. After being brought up to pressure they are cooked for four hours at 55 p.s.i., and thus, of course, they are all done at the same time. We put in 4½% of high-calcium lime, 2 to 3% of soda ash, and 1% of sodium sulphite. There is no seasoning of stock in the pit. Some of it, on discharge from the digester, falls into the conveyor and is in the beater within a matter of a few minutes. Some of it will lie there for up to eight hours. We do not cook deteriorated straw from the tops of our stacks in the same manner as we cook the rest of our straw. We pulp it separately, using a less drastic cook, than on the regular straw. And aside from the fiber loss, the quality of the stock that we get from these tops is better than might be expected. It takes us about an hour to reach cooking pressure after the rotary is sealed, and it takes from 35 to 40 minutes to dump the rotary after the cook. We have no record of the amount of drain liquor, but we try to keep that down to a minimum.

In the beater room the beaters are charged with the roll up off the bed plate. The two washers on each beater operate continuously during the time that the stock is in the beater. After the beater is charged, the roll is lowered somewhat. How closely we approach the bed plate depends upon the stock. We do not go down all the way at once; we do that at intervals, and there is where the practical beater engineer has to use his judgment. The stock is kept in the beater until it reaches the point where he is satisfied with its appearance and feel, and then a sample is laid up for each beater so that the superintendent can check the operation of the beater engineer and make corrections as indicated.

I want to say a few words about our experience with disk refiners. Our installation was on an experimental and temporary basis and rather crude, and it does not enable us to get all the answers. We have found that it makes our operation much more flexible, in having continuous operation which can be adjusted at any time to get almost immediate results. We can do a better job of preparing the stock in the refiner than we have ever been able to do with the beater. It has enabled us to use substitute materials for straw, such as flax shives and soybean stalks. Another important use we found for the refiner was in connection with charred straw resulting from burned stacks. In the past we have had to discard all bales having charred straw because it went through our equipment and made holes in the sheet. However, with this refiner, the charred parts are reduced to fine particles that mostly wash out. In a fire that we had this summer, our fiber loss was very low because we could use all the residue. The stock supplied to this machine is not adequate to load it to capacity. We are putting through about a ton and a half, to a ton and three quarters, dry basis, stock per hour.

You have those paper sheet samples before you. I do not know how they rate in quality with production in the industry. If they are the worst sheet on the market you probably will not tell me, and if they are the best you probably will not say anything about it. So I am going to assume they are about average.

Dr. Aronovsky: Thank you, Mr. Bush. The next talk on the program will be by Harry L. Lamb, General Superintendent of the River Raisin Paper Co., Monroe, Mich., on "Straw Pulp and Stock Preparation."

Mr. Lamb: This paper was prepared by our chemist, Mr. Knack, and I am just pinch-hitting for him.

The purpose of these remarks is to review briefly the present operating practice in straw pulping and stock preparation. There are, of course, practices common to the industry not known by the author that will be revealed in the discussions.

The steps involved in the manufacture of strawboard from straw pulp are essentially: (1) Dumping the cooker; (2) conveying or otherwise moving the pulp to the next step in the process which may be; (3) beating or macerating; (4) washing; (5) refining; and (6) screening.

1. The cooker is usually emptied after the steam pressure has been reduced by venting the steam to atmosphere by removing the charging cover and revolving the cooker. The discharged pulp is usually conveyed to the next step in process, though in a few mills it is washed into a flume from which it may be pumped. The cooker may be completely emptied after venting if storage for the cooked straw is provided or it may be emptied only as rapidly as needed in the next process step. Some mills provide storage for as much as several days' supply of cooked straw, while others withdraw directly from the cookers for processing.

2. The second step is to macerate or beat the straw pulp into such a condition that it can be handled by pumping. The most common method of handling is to convey the pulp into beaters where the beating action separates the fibre bundles. Usually in this type of equipment, washing is accomplished at the same time using bucket-type washers. The other type of equipment used is the sugar press. This piece of equipment accomplishes sufficient maceration so that the stock can be subsequently slurred and pumped. The action of the sugar press also removes a large portion of the waste liquor from the pulp in a concentrated form. In some mills the pulp from the press is pumped to beaters for some brushing and for washing. In at least one mill the stock is refined in rod mills and washed on a side hill screen.

4. Washing, as is apparent from the preceding remarks, is usually accomplished in connection with some part of the beating or pressing operation, usually in beaters.

5. Refining. Some work is done on the fiber in the beaters where beaters are used. In some mills a refiner is used in connection with the washing beaters. These refiners are either the wide bar plug type or disk refiners. In most mills the finishing is done in jordans which accomplish some cutting as well as brushing. In some mills waste paper is broken and refined in equipment separate from the straw equipment. In mills using beaters the paper stock may be added to the beaters and beaten with the straw or it may be beaten separately and blended in the stock chests.

6. Screening. The mixed furnish for the paper machine is usually screened. Flat screens are sometimes used and at the present time the Jonsson vibrating screen is gaining favor for screening straw pulp at the paper machine.

With some variation these are the essential steps in the process of preparing straw pulp for the paper machine.

Dr. Aronovsky: Thank you, Harry. B. F. Stahl of the Terre Haute Paper Co., will now speak on "Some Problems Arising from Modified Strawboard Cooking Procedures."

Mr. Stahl: There is a lot in this era that we are going through now that cannot be brought into my paper because of the more or less secret nature of the developmental work of some of the competing companies. In this paper I can only say what we have done in Terre Haute on variations from the old lime-caustic cook we have normally used.

Attempts to improve strawboard quality as regards compression tests have led to other major developments wherein the average strawboard mill finds itself seriously deficient.

Variations in cooking components and procedure appear to be the starting point of every mill in their search for a harder sheet. All of us know that, without additives in the finished board, the best way to start toward a hard sheet is to keep the cooked stock as raw as possible. This has led, on several occasions, to difficulty in dumping the stock from the rotary digesters. With normal soft-cooked straw two rotaries dumping at any one time are sufficient to fill a one-ton beater rapidly, say in 15 minutes. In some of the recent experimental work, however, as many as six rotaries took an hour to fill one beater. The very raw stock just cannot get out of the opening in the digester.

When the above takes place it is safe to say that beaters are going to get plugged because the rolls will not take the stock readily. With such hard stock it is necessary to set the beater roll down on the bedplate and let it stay there throughout the beater cycle.

In some cases the beater cycle is as much as 2½ hours. This practice seems to hydrate the stock too much and causes the sheet to form slowly on the machine and to dry slowly, thereby losing production.

A plugged beater is something everyone wants to avoid but a raw cook can bring about a situation bad enough to shut down the machines of a small mill if the beater room gets far enough behind in refining. Furthermore, the long period of refining in beaters, to a point where jordans will handle the stock, causes the pulp to lose some characteristics that produce a hard sheet of board. Some of the natural fiber bundles must necessarily be broken down and the period of

hydration, as mentioned above, is too long for good machine drying conditions.

The period of beating and the setting of the beater roll depends on the equipment that can finish the refining process. In other words, if a jordan's capacity is small the beater cycle must be increased in order to reduce the pulp to a condition where the finishing jordans can handle it. To attempt to apply stiffening agents at the jordan appears to be rather useless even though such additives would seem to be diffused throughout the stock more completely at the jordan.

Attempts to add stiffening agents at the suction tail roll of the machine, by spraying, have been tried by at least one mill. Such benefits as would seem possible here are thought to be lost either through loss of the reagent at the suction top press roll or squeezed out of the sheet at the first press.

Dryer applications of coatings have been tried, too, without apparent success, principally because of the folly of putting more moisture into the sheet at this stage when we have just used the full capacity of the wet end to remove all possible moisture. If the sheet hits the dryers at 33% pulp and 67% moisture we must utilize the full dryer section to evaporate two tons of water for every ton of paper produced. Thus, there seems to be little sense in applying moist additives at the dryers.

Calender applications, for a mill with an open waste-water system, appear to be best but care must be used in keeping the applied product fluid enough to prevent sticking of the calender rolls.

Some of the problems, then, resolve themselves into the following:

1. What can be done with mixtures of straw of various sorts, weeds, etc., to produce an evenly cooked pulp at low cost?
2. What equipment is necessary to reduce the refining cycle to a bare minimum whereby the pulp mill will not be too hydrated and cause a slowing down of machine operations?
3. Will a press of the sugar press type be a better investment for treatment prior to beating and washing than a multiple disk refiner following the beating operation?
4. Will more cylinders on the machine allow a more raw stock to be run at maximum speeds?
5. Will a more acid or more alkaline pulp run better without causing variations in vat levels and in the vacuum on the suction presses?

Dr. Aronovsky: Thank you, Frank. The last speaker on this panel, N. F. Wilson of the Alton Boxboard Co., Alton, Ill., will discuss "Single-fill vs. Multifill Cooking of Straw."

Mr. Wilson: Dr. Aronovsky, gentlemen. The subject of single-fill versus multifill seems to me to be a simple matter. I have not prepared a written talk to be read on the subject. I follow some excellent discussions and understand that my talk should be limited to about 15 minutes. There is a great deal of difference in opinion as to how to make good straw pulp. In various plants, the decision as to whether a stock is good or bad very often is made on the basis of handling some of the cooked stock. It is considered good if it will go through the refining equipment and make some kind of a sheet of paper. When we look at the finished sheet of paper, we ought to go back and ask ourselves whether that judgment is sound. Can we decide on what sort of stock we want? Some of us want to find some kind of special cook that may help, feeling that there is a sort of witchcraft involved in cooking straw. Some mills are apparently better off as to equipment. Some would like to think that if they are not making a good sheet of straw they can blame it on the equipment. I doubt if that is true because it is possible for some of the mills making a poor grade of straw to improve it greatly with very little change in equipment. The equipment that needs improving is the thinking, by adopting a practical, unbiased point of view toward the whole process.

Now, I am telling you frankly what I think about the situation and also want to go into some of the processes that I think might improve the situation and into some that we are using at Alton. We have been using one fill at the Alton mill for about 10 years. We have used various cooks, mostly kraft-type. Some of them have been made with 200 pounds of lime, 50 pounds of caustic soda, and 100 pounds of sodium sulphide for 4 tons of straw. Then, we have used 275 pounds of lime and 110 pounds of sodium sulphide. The present cook that is working very nicely is 125 pounds of lime, 175 pounds of caustic soda, 100 pounds of sulphur, and 1800 gallons of water. This is put in the rotary and the steam pressure is brought up to 45 pounds in about 45 minutes. The cooking time is 120 minutes, rolling 60 minutes, blow-down 45 minutes, and about 30 minutes to dump. There are about 2 to 3 gallons of liquor drained from the rotary. We do some washing in a large breaker beater without a bed plate, and the recovered chemical is sent back as make-up liquor, resulting in a saving of chemical of between 5 and 10 per cent. The straw is then beaten for 45 minutes at 5% consistency. The beaten stock is left long, about 2 to 3 inches. (Straw can be ruined in the beater by too much beating, resulting in chopped-up straw with too much fines). Beaten stock goes to a claflin and then through another claflin of the same type. Then the somewhat defibered stock goes through two Miami No. 2 jordans in parallel. Fifteen to 20% of kraft clippings is beaten, seperately refined, and added to the pulp. That is a brief outline of the Alton Mill operation.

In Carlyle we have a different type of equipment and operation. Here we use 4½ tons of straw per rotary. This mill uses a sodium sulphite cook. I might say here that some of the mills, according to the excellent report put out by Mr. Stahl, are using very small amounts of sodium sulphite, and imagine they have sulphite cooks—adding a few spoonsful, if you please, per hundred gallons of water and calling it a sulphite cook! I do not think they are getting anything for their money when they do that. The cook which gives best results at Carlyle may not be suitable for other mills, but it worked nicely in an experimental run and is still in use with a slight change—325 pounds of lime, 65 pounds of caustic soda, 150 pounds of sodium sulphite, and 1400 gallons of water; cooked 10 hours at 35 pounds. A stock which is near neutral results.

This stock is sent directly to the beater and is in the beater 2 hours; the roll is lowered for 45 minutes. Alum is added to bring the pH to about 6.5; that takes about 20 to 40 pounds of alum—a low amount because the system is completely closed. There is no washing and everything remains in the stock. The stock goes through two jordans and Jonsson screens before it is run onto the machine. The fiber is excellent and long. The tests on the finished sheet are established at 9 and 10 points, 32 to 33 pounds per 1000 square feet, and about 30 to 33 pounds Mullen. When 6 rolls were corrugated and sampled, an average flat crush of 45 p.s.i. was obtained which shows that something can be done in bringing up the flat crush. Whether or not everyone else can take this formula and do the same thing I cannot say, but with certain modifications, I feel certain it could be done.

Now, we might consider some of the constituents in the straw that have a bearing upon the problem of pulping. We have lignin or lignone which is a resinous material that can be liberated by acid. Then we have ligno-cellulose, which we do not want to destroy, and our chemicals should have a selective action so this part will undergo a minimum of attack, to give us more stiffness. The hemicellulose if hydrated too much will, of course, give us a brittle sheet. We do not want to beat too long for that reason.

Now, regarding the single-fill vs. multifill cooking, there are a number of points in favor of the single-fill. First, it is a short cook. We can get more tons per rotary per day with the single-fill; that is helpful in a mill that has insufficient rotary capacity. We can use a definite formula. We can count upon so many pounds, so many gallons, so many bales of straw, cooked so long. There is a definite time cycle. There is less labor. There is not the frequent reopening and closing the heads of the digesters. There is a lower water ratio. There is less condensation and less variation in the amount of water necessary, and, of course, the result is more even cooking. When you are using three or four fills, as has been pointed out before, the first fill takes up most of the liquor, the second and third fill get less and less so that there is quite a variation in the cooking by the multiple-fill method.

Temperature of the cook is important, too. Usually the steam pressure with multiple fills is lower. That means that the lignin cannot be made soluble as readily as it can at higher temperatures. The even cooking of the single-fill allows the use of a minimum of beating to get uniform beaten stock. And that is important. Another disadvantage

in the multiple-fill cook is that there is a tendency to feel that it is an economic measure, as it is possible to exhaust the chemical and use every penny put into the chemical. That is a mistake. It is better to have an excess of chemicals so that when you have stopped the cook you have some chemical left over. Then there is the washing. It is difficult to wash chemicals from the stock. The equipment is usually inefficient. With different chemicals, we have different rates of washability. There is a certain amount of chemicals that cannot be washed from the straw. With caustic soda, we might have a residual of 15% that could not be washed out; with caustic soda and sulphite combination, about 5%; and with soda ash, about $1^1/_2$%. The residual with lime would be about 1%; with lime-caustic soda, $^1/_2$%; and with lime-caustic soda and sulphite, about $^1/_4$ per cent.

Tied in with this is the chemical attack upon the pulp. Different chemicals have different rates of attack. We cannot just say that the hydroxyl ion is the thing that does the cooking and that we can take a chemical equivalent of some other alkali and get the same results. I have some estimates of a few chemical ratios. Soda ash has a ratio of about 1:25; that is, about 25 times as much attack on lignin as on cellulose; sulphite about 1:15; lime about 1:40; caustic soda and sulphite 1:40; caustic soda and lime about 1:5; caustic soda by itself 1:2; and lime, caustic soda, and sulfite about 1:7. Now this last one has less selective action upon lignin than some other combinations of chemicals, and I feel that perhaps it is a mistake with a formula of this type to cook to a point where the knots or nodes are thoroughly softened. If that is done, the essential part of the fiber is overcooked. It is better to screen out some of those nodes and leave the stock more raw.

Lastly, I want to point out the importance of examining the fiber in the finished sheet. We have some competition in the form of chemi-pulp paper. What kind of fiber is in this paper? It is different from straw, and when we look at it under the microscope, we find that it is a rather coarse material with more long bundles of fibers, and some completely separated. We find some of the ends of the bundles frayed out. The fiber end looks something like a hand with a number of fingers, and, it is conceivable that these fingers might intermesh to give more compression. Photographs of fibers are very helpful in comparing different pulps.

Dr. Aronovsky: Thank you, Norval. A number of points have been raised in these four talks. I am sure that not all of you agree with some of them. Those are the points which we would like to discuss here. Mr. Wilson, do you have any complaints from Altonites when the gases are liberated from this kraft blow-down.

Mr. Wilson: Very few.

Mr. Wisman: Mr. Bush, when you say that you put 10,000 pounds of straw in each rotary, do you actually weigh 5 tons into each rotary or do you weigh 40 tons and put them into 8 rotaries?

Mr. Bush: That is it, 40 tons into 8 rotaries. Each fill is rodded similarly and the straw is thus divided uniformly between the 8 rotaries.

Mr. Krancher: Mr. Bush, have you noticed any appreciable improvement in furnish by reason of using your refiner?

Mr. Bush: I cannot say positively that we have. Only about a third of the furnish goes through the refiner. And while our test is better than it has been, I would hestitate to attribute it to the refiner because of the variation in straw. During the heavy stacking season, we naturally put the best straw in the stacks and we get the poorer straw into the mills. After that, we have better quality of straw, and that may account for the improvement more than anything else.

Mr. Krancher: Do you vary the setting on the refiner to suit your stock, or do you run it at one setting?

Mr. Bush: We vary that setting every day to get the results we want, and that is determined by a number of variables in the stock.

Dr. Aronovsky: Mr. Bush, what is the ratio of chemicals that you have found best for flax shives or soybeans, as compared to straw?

Mr. Bush: Well, the cook has to be much more drastic on either of those and, off-hand, I would say it is practically double what we use for straw.

Mr. Owen: Mr. Wilson, the cooks at Alton and Carlyle are different, are they not?

Mr. Wilson: Yes, sir. The Carlyle mill has a closed system and we have found the sulphite cook desirable. It gives a sheet that will stand aging since there is little residual alkali to weaken it.

Mr. Stone (*Stone Container Corp.*): Did you take a 1-square-inch sheet to determine that 45-pound test?

Mr. Wilson: We run a test on 5 square inches ($1^2/_3$ by 3) or 9 square inches (3 by 3). Results compare fairly well. With larger samples, there is a difference. Some people have been testing flat crush on a 1-foot square sample. These results do not check with the smaller samples.

Dr. Aronovsky: Mr. Wilson raised some points on single- vs. multifill which I am sure are somewhat controversial. Does someone here take exception to some of the statements he made?

Mr. Burns: I would be interested in knowing if he has any real evidence that a one-fill system does give him a more uniform product?

Mr. Wilson: Our experiments have not been made for the purpose of showing the difference. However, with two or three fills, you generally put as many bales as possible in the first fill. In the second fill you again put in as many as possible. The third fill is the same. No two rotaries have had the same number of bales in the first fill or in the second and third fills. You have a different ratio of fiber-to-cooking liquor in each case, and you may end up with one rotary that has 50 bales more than another. You have much more chance for variance in multifill cooking.

Mr. Shatto (*Fort Wayne Corrugated Paper Co.*): I have tried it both ways and a single-fill was just as nonuniform as a two-fill system. Of course, I base that on the different weights of the bales we get.

Mr. Wilson: With a single-fill you have less stock to cook. With multifill, sometimes a rotary is a little raw, and very likely it is run through with a lot of other stock in the hope that it will not be noticed.

Mr. Stone: Mr. Stahl, have you any results on your so-called semi-raw cook?

Mr. Stahl: We have found in 3 or 4 days of one run with sulphite that we obtained an improved sheet, but we cannot handle it because of the lack of refining equipment. What we would like to use are caustic and sodium sulphite.

Mr. Stone: You have not measured the results though by testing equipment?

Mr. Stahl: By outside testing laboratories, yes. We use the Riehle compression test on a $^1/_2$- by 6-inch strip. A Chicago firm has given us a standard of 40 pounds, machine direction, and 30 pounds cross direction. The old lime and caustic cook just barely made that standard. This modified cook with lime, caustic, and neutral sodium sulphite is running on an average of 55 machine direction to 35 cross direction.

Mr. Stanley (*Dresden Paper Mills*): Mr. Bush, is the amount of water added to your chemical important in connection with the moisture content of the straw?

Mr. Bush: We do not know for sure. We try to keep the drain water from our rotaries as low as possible. We think we get better and more uniform results by not having an excess amount of water.

Dr. Aronovsky: Would it be practical to weigh the bales into the rotary with a weightometer, or something of that sort, so that whether you have heavy or light bales, you will know how much chemical you have to add?

Dr. Johnston: That is what we do. The bales are brought into the rotary room on a truck that passes over a scale. When the rotaries are loaded the weights are added up by the man in charge and he calculates the exact amount of lime to be added. We use a single-fill system.

Mr. Krancher: How do you take into account the moisture content of the bales?

Dr. Johnston: Through inspection of the bale. If we have wet straw we have to do a little figuring. We do not use a Delmhorst moisture meter at that spot. Under our conditions, we get along pretty well by just estimating the amount of water.

Mr. Shatto: Mr. Krancher, you have had some experience with the cutting of straw. By cutting the straw, do you expect better uniformity in the cooks?

Mr. Krancher: Yes. We found that we were able in test runs to shorten our over-all cycle; our dumping time, for instance, was shortened from an hour to about 15 minutes. We could have dumped it in 5 or 6 minutes. That was a comparatively dry cook, but because the fiber was short, it passed the small entrance of the digester opening very readily.

Mr. Shatto: Under those circumstances, you could actually improve the quality of your sheet of paper?

Mr. Krancher: I believe so. That is my opinion. Our problem is to get the proper type of equipment to cut the straw at the rate we want to fill the digester.

Mr. Shatto: Our greatest trouble in pulping is the nonuniformity of our cooks, and, naturally, our quality goes up and down.

Mr. Getty *(Fort Wayne Corrugated Paper Co.)*: Mr. Stahl, you made mention of additives in the way of coatings and impregnation to increase stiffness. I would like to draw on your experience and that of others, particularly with the new synthetic resins that are available.

Mr. Stahl: About all we tried were various concentrations of CMC and also silicate of soda. That was a calender stack application. We tried spraying it, but it stuck on the calender rolls. It was obviously too concentrated a mix. It seems odd to me that the silicate that is already in straw is cooked out and thrown away, and then we try to put silicate back again. If we could somehow use our concentrated cooking liquor extracts and put the silicate back in it as a coating this might work out pretty well economically and improve the sheet too.

Mr. Getty: I think you are on the right track. Your entire program, pretty much in line with what we discussed in Chicago, is fine from a long-range view; you are certainly attacking it fundamentally. But what are we going to do right now, to meet chem-fiber? It strikes me that if some way can be developed to utilize synthetic resins in the way of impregnations, coatings, and so on, we may get improved stiffness. That may be a stepping stone until you get sufficient fundamental data to build up your sheet. I do not think there is any denying the fact that chem-fiber surpasses straw. I am beginning to disclaim any credits for the Riehle test. It is of little or no value until you put the sheet through a corrugator. If you take a piece of strawboard and put it through the corrugator under a set condition of moisture and present-day high speed, you are going to come out with a far different result than you did 6 years ago.

Anonymous: Yesterday, Mr. Blandin and Dr. Aronovsky brought in tear resistance which they seem to feel has a great effect. I do not understand what that would have to do with a finished box.

Mr. Stahl: We are getting into a new high-speed realm in the manufacture of boxes that we did not know 4 or 5 years ago. From a practical standpoint tear resistance in handling that corrugating medium in the high-speed corrugators is important.

Mr. Lamb: I was just wondering whether anybody had tried silicate and starch mixed together, boiled, and then put in the beaters and run through on the machine. I have tried it on straw and it worked pretty well and gave a sheet with good rattle.

Mr. Gillespie *(Gaylord Container Corp.)*: In regard to these resins, we make a semikraft corrugated sheet, and I think that insofar as it is strongly alkaline it might be similar to your straw stock. Many of these resins like urea-formaldehyde, phenolics, and melamine do not polymerize except under acid condition. You are not likely to accomplish much if you add the ureas, melamines, and phenolics to an alkaline system. We have tried various other resins, including styrene and the coumarine types, without adding very much stiffness to our particular type of sheet. There is a new type of resin that the Bakelite people are putting out, which is supposed to be compatible with alkaline stocks. It is a ketonic type of resin and we are in the process of experimenting with it right now. Theoretically, it seems to offer much more promise than some of these other types that only polymerize under acid conditions.

Mr. Getty: That is what I had in mind in raising this question. Perhaps that may be the stop-gap answer to our problems until we get back to the real conservation of whatever chemical properties straw might have.

Mr. Gillespie: I would just like to mention a word about refiners. Mr. Krancher asked whether refiners would produce a better stock than beaters. We have never used beaters, but we use refiners and jordans. Comparing refiners with jordans, the answer is very definitely yes. I think the way the refiners are handled means a lot. Our approach has been similar to Mr. Bush's, in that we feed the refiner with high-density stock—around 8 to 9%. The type of stock you get from it, at least in our particular case, is far superior to what we get through a jordan. In our revamped process, we are practically eliminating jordans, except for one just before the machine. We will use disk refiners entirely. By feeding our refiners at 8% consistency, our power consumption is very low. I think the problem of disk life in refiners is important. We get what we think is rather long life out of the disks, but we wonder if that is good judgment. As the disks wear down, you either have to screw them up tighter or you have to cut down capacity. If you cut capacity you increase the power consumption per ton of stock, and it seems to us there is an optimum time to throw the disks away, rather than talk about extending their life.

Mr. Bush: I think you are absolutely right—that is about the way we determine when to discard the disks and save power.

Dr. Aronovsky: Gentlemen, before we adjourn for our plant inspection trip, I want to thank the members of the panels for their splendid papers and all of you for joining in the discussions so freely. I also want to thank Mr. Sutcliffe for operating the recorder.

After adjournment, an inspection tour was made of the Peoria plant of Hiram Walker & Sons, Inc., followed by a social hour at the plant. At the dinner in the evening, W. F. Gillespie spoke briefly on the scope and accomplishments of TAPPI. The main talk of the evening was given by L. J. Fletcher, of the Caterpillar Tractor Co., on "Community Relations—Why?"

Committee Meeting—Tuesday, November 16

Dr. Aronovsky described briefly the structure of the Fibrous Agricultural Residues Committee and the projects of the various subcommittees. H. M. Blandin, chairman of the subcommittee on Procurement, Storage, and Preservation, was unable to be present at this meeting, but he left a report which was read by Dr. Aronovsky. This report dealt mainly with the progress obtained in the industry during the year on the preservation of straw in ricks.

There was considerable discussion after this report among the men who were directly interested in these preservation tests. Messrs. Stahl, Bush, Little, Wisman, Krancher, Shatto, Goetz, Adair, and Shew described their experiences in this cooperative straw preservation test. All agreed that borax seemed to be the most efficient and economical preservative for this purpose, and that they are continuing the test during the present storage year using borax both in the refined and crude forms. The straw, after treatment with borax and approximately a year's storage exposed to weathering and rain, had changed but slightly or not at all. The treated bales were firm and could be dropped from the rick without breaking, while the untreated bales used as controls were soft and in some cases mushy, and disintegrated when dropped from the top of the rick.

Some other methods of preserving straw are being attempted this year. The Alton Boxboard Co. is experimenting with asphalt-treated paper covering. The Hinde & Dauch Paper Co., at Fort Madison, Ia., is experimenting with piling loose straw on top of the rick in a manner similar to that of thatch on a roof.

Mr. Krancher reported that on the basis of their results last year, they expect to save about $5000 a year on their 25 ricks. Borax-treated straw run through the mill seems to be no different than the ordinary straw insofar as its handleability, cooking, and papermaking properties are concerned. Dr. Aronovsky emphasized the fact that by close cooperation between the strawboard mills and the chemical preservative manufacturers, it was possible to obtain conclusive results in one year. If only one or two companies had carried on this work, it would have taken a number of years and the results would not have been as comparable or as conclusive.

As soon as the data of the several mills can be brought together and correlated, these results will be written up in the form of a formal report.

Dr. Aronovsky, chairman of the subcommittee Fiber Classification, reported that the work on pulping straws from the dominant species of the main wheat areas has begun. The straws included are from Northern Dark Spring wheat from the Dakotas, Soft Winter wheat from Illinois, Hard Winter wheat from the Kansas-Nebraska area, Semolina wheat from Montana, and White wheat from the west coast. Studies on the stiffer Clinton oats straw are also being included in this series.

B. F. Stahl, reporting as chairman of the subcommittee on Pulping, stated that the work of this committee was included in his report given the previous day, and that he had nothing

further to add at this time. A chemist from the Crown-Zellerbach Corp., of Camas, Wash., had joined this subcommittee.

M. F. Knack, chairman of the subcommittee on Board and Paper Manufacture, was unable to be present. Dr. Aronovsky stated, however, that Mr. Knack is completing a survey of the equipment available at the various strawboard mills and will probably make a report on this survey at the annual meeting in New York.

Norval F. Wilson, chairman of the subcommittee on Testing, then brought up the subject of the laboratory corrugator. He described briefly the progress made on developing such an apparatus and showed slides of a preliminary unit designed by the Thwing-Albert Instrument Co. This instrument consisted of a flat corrugated platen. The paper is fastened at one end and held under tension by means of a weight at the other end of this platen. The corrugations are produced by dropping rods in consecutive order into the depressions of the corrugated platen. A liner sheet coated with adhesive (or the adhesive may be touched to the tips of the corrugations of the paper) is then placed over the corrugated paper and held there until the adhesive sets. The rods are then dropped out and the single-face corrugated paper is ready for testing. This is, of course, only a rough description of the operation of the proposed apparatus.

There was considerable discussion regarding this instrument, in which practically everyone present joined. Mr. Wilson pointed out that the value of such an instrument lay in the possibility of obtaining a suitable test on a small sample and not necessarily a roll of paper. Such a test would be of no value by itself until it has been correlated with a large number of actual tests of the commercial product run through regular corrugating procedures in box plants. Only if a definite correlation between the laboratory instrument test and the end-use tests on the finished boxes were obtained would this laboratory instrument and test be considered satisfactory.

Mr. Wilson stated that he would prefer the A flute-type of corrugation; but that with such an instrument it would be possible to produce the B and C flutes, or for that matter, flutes even larger than the standard A flute. In reply to a question as to why a small-scale regular corrugator could not be used, it was pointed out that such a unit would require paper in rolls; and even in that event, the tests on such a corrugator would have to be correlated with a large number of actual box plant commercial corrugating runs. Also, such a corrugator would be quite expensive since the cost is not so much in the amount of material involved but in the fabrication. P. S. Bolton, of the Robert Gair Co., emphasized the fact that a sheet of paper on the corrugator undergoes many types of treatment, such as the application of heat, pressure, tension, and shear. He believed that that is the main reason why a ring test does not indicate how the sheet will act in the corrugator. He stated that the Institute of Paper Chemistry is setting up an elaborate long-range program to study the fundamentals of corrugating. K. W. Max also of the Robert Gair Co. pointed out that with the instrument under discussion the rods are in contact only in the valley of the flute and there is no pressure on the straight wall of the flute such as is obtained in the commercial type of corrugator. Dr. Aronovsky suggested that perhaps the Thwing-Albert people could use a corrugated roll to run over the paper on the platen and use the rods only to hold the corrugations in place until a liner has been applied. As all present agreed to this, it was suggested that Mr. Wilson take up this point with the manufacturers of the apparatus. It was also suggested that it would be desirable to have both the corrugated top roll and the platen equipped with a means for heat control.

Mr. Max stated that they had done considerable work on determining the conditions of shear, temperature, and pressure developed in the corrugating procedure. They have combined these values in an arbitrary manner which they call the "plastic factor." Mr. Max also corroborated Mr. Bolton's remarks that there seemed to be no substantial correlation between the ring and crush tests for corrugating 9-point board.

The moisture content of the sheet in the corrugator is of great importance. In view of the size of the proposed laboratory instrument, it was thought that the best procedure was to season the sample at the relative humidity required to give the desired moisture content, rather than to try to add water or steam in the corrugating unit. Mr. Wells stated that while the proposed laboratory corrugator did not seem to fit all of the requirements, it was a step in the right direction. Although this instrument may not give the complete answer to the corrugating problems, we cannot afford to wait until somebody else solves those problems, but should try instead to develop this or some other instrument which seems to show promise. Dr. Aronovsky again stated that this or any similar instrument would be of value only after exhaustive tests and correlation with the commercial corrugators in box plants. Mr. Bush and Mr. Palm agreed that the proposed instrument has possibilities. They emphasized the point that under the present conditions a poor box may not necessarily be the fault of the corrugating paper, although that is where the trouble is generally placed. All agreed that good paper may be easily spoiled by faulty corrugating equipment or poor operation in the box plant.

It was suggested that Mr. Wilson take up the ideas expressed here with the Thwing-Albert Co. and help them develop a laboratory corrugator which would include as many of these suggestions as possible. Mr. Max reiterated his statement that corrugating involves the simultaneous action of temperature, pressure, and shear, and that the design of the instrument should be such as to take these into consideration.

Dr. Aronovsky thanked the members of the committee and guests who were present at this meeting for their wholehearted cooperation, frank discussions, and suggestions.

The two-day meeting was concluded with a tour of the Northern Laboratory followed by plant tours of the Bemis Brothers Bag Co. in Peoria, and the new diesel engine plant of the Caterpillar Tractor Co. in East Peoria.

This was one of the most successful meetings held under the auspices of the Fibrous Agricultural Residues Committee. The discussions were frank and everyone joined in them. All who attended expressed the feeling that they had enjoyed the meeting and profited by it.

TAPPI Fibrous Agricultural Residues Conference Group at Terre Haute, Ind. November 7, 1949

Wood Research at the N. Y. State College of Forestry

EDWIN C. JAHN

Wood is a bulky commodity. The best way the United States can be sure of having an abundance of wood available to meet the exigencies of any national emergency is to have this wood stock-piled on the stump near the great wood-using and industrial centers of the country. This is not the case today, for, although 77% of the forest land lies in the eastern United States, 65% of our sawtimber volume occurs in the West on only 23% of the forest land.

Most of this great forest area in the East is in numerous small holdings and has poor-quality timber and is poorly managed. Our nation's most critical forestry problem is how to bring into good productivity the 261,000,000 acres of forest land located in these small holdings, mainly in the East. All forest land should be brought into efficient productivity in order to supply wood for our national economy, to provide wood for national defense, and to create and supply a stable economic base for much of rural America.

WOOD SUPPLY

The New York State College of Forestry at the Pack Demonstration Forest at Warrensburg has made a substantial contribution to this subject. In a study of the management of white pine during the past twenty-year period, the College has doubled the timber volume on the Pack Demonstration Forest and at the same time has maintained a substantial cut to support local needs and local employment. This cut has been taken primarily from trees infected with blister rust or trees so badly crowded that they otherwise would have died. As a result, accumulation of stumpage has been almost as rapid as would have been the case had no cutting taken place. A further advantage is that the quality of the wood has also been greatly improved by the cutting practices used.

The College has perfected a truck-mounted, two-man portable sawmill that can be set up in one and a half hours and by which two men can saw from three to four thousand board feet of lumber per day. This lumber is sawed from logs five to eleven inches in diameter and eight feet long, too small in size to be handled by the common sawmill. This material normally goes to waste in the forest. Experiments are being made on uses for pine poles in small sizes such as are removed in thinnings. The more uses that can be found for such materials, the greater the possibilities of relieving heavy demands on sawtimber-sized trees, and of developing good productive timber stands on small holdings.

The College is also experimenting on how to manage hardwood forests so as to obtain a high yield of useful material and a minimum of cull. Of paramount importance in time of emergency is the availability of local timber supplies. The College has been studying timber availability and the use of abandoned farmlands in New York State in an effort to determine how such land can support a local population and also build up a substantial forest income. These studies reveal many interesting facts—that much timberland is owned in thousands of small parcels, too small to attract the ordinary lumber operator, that most of the woodlands are in poor condition, that they are stocked with beech and other unpopular species, and oftentimes contain cull trees that occupy ground but produce no useful products. From these studies an action program will be outlined to rehabilitate such woodlands so that they may effectively contribute toward building up a stockpile of valuable timber on the stump.

Edwin C. Jahn, Director of Research, New York State College of Forestry, Syracuse, N. Y.

MECHANICAL PROPERTIES OF WOOD

The New York State College of Forestry has long been engaged in preparing a collection of authenticated wood specimens selected from trees and backed up by herbarium specimens from the same trees. This study was initiated by and is under the direction of Dr. H. P. Brown, one of the world's leading wood technologists. Complete sets of authenticated samples of all such wood collected are sent to ten cooperating institutions and many samples go to other contributing institutions. This collection is now sufficiently large to be of great scientific value for special studies of wood structure and mechanical and physical properties of wood. The College is also making a detailed study of the anatomical and physical property differences between basswood of sprout and seedling origin.

Several studies have been made of glues and adhesives, their bonding qualities when used with wood and the nature of the glue-wood bond. Recently the College has been engaged in studying the use of high-frequency electricity in curing glue lines in massive wood assemblies. This work is now well under way. We expect to determine ultimately whether glue joints cured by high-frequency heating differ in strength and other properties from those cured by the direct application of external heating. Various types of adhesives are being studied as well as various methods of preparing surfaces prior to gluing.

The dielectric properties of both wood and glue have been determined at several radio frequencies. It was found that the perpendicular-to-grain dielectric constant for wood is dependent primarily upon density and moisture content regardless of the kind of wood. The dielectric constant decreases and the frequency is increased from 2 to 15 megacycles per second. The dielectric constant varies in a straight-line relationship to moisture content above the fiber saturation point. At lower moisture contents the relationship varies exponentially. It was demonstrated that the parallel-to-grain dielectric constant is 30 to 50% higher than the corresponding perpendicular-to-grain constant. Power factor and resistivity of a given kind of wood are dependent primarily upon moisture content. When the wood is oven-dry there is a significant, but weak, correlation between its power factor and density, irrespective of the kind of wood. A relatively strong, but negative, correlation exists between the resistivity and the density of the wood.

WOOD CHEMISTRY

The New York State College of Forestry has been active in cellulose and wood chemistry research for many years. Most of this work has been of a fundamental nature. The present program includes a study of cellulose-synthetic resin copolymers, the cross linking of cellulose and of pentosans, and plastics and industrial chemicals from lignin. The project on cellulose-synthetic resin copolymers was started last fall. The problem is being attacked in two ways, one by forming cellulose derivatives with an active functional group (unsaturated, hydroxy, carboxyl, etc.) on which addition or condensation reactions may take place and the other by chain transfer reactions between cellulose derivatives and synthetic resin monomers. It is expected that such cellulose copolymers would have unusual properties. The hygroscopicity and dimensional change of the cellulose and the brittleness of the synthetic resins should be decreased in such a copolymer, and the properties of toughness and dimensional stability enhanced.

Studies are now in progress on the nature of the formaldehyde-cellulose reaction in an effort to prove whether or not cross-linking takes place. It has been shown in a project recently completed at the college that formaldehyde

reacts with purified birch pentosans converting them from a material easily soluble in dilute caustic soda to a substance resistant to solution even in strong caustic soda. A pentosan-rich sulphate pulp containing 3 to 4% formaldehyde was prepared which is completely insoluble in 17.5% caustic soda solution. Moreover, a pentosan-rich pulp with as little as 0.74% formaldehyde has low chemical activity and fails to form a soluble xanthate or carboxymethyl ether.

Lignin research reported in the literature on plastics has thus far been largely empirical and the results have been none too satisfactory. Lignin remains potentially a great source of raw material for plastics and industrial organic chemicals. The College is now studying certain cleavage products of lignin. Starting with vanillin, which can be prepared in large amounts from the lignin in the waste liquors of the sulphite pulp industry, substituted styrenes have been prepared, namely 3-methoxy 4-acetoxy-styrene and 3-methoxy 4-hydroxy styrene, and the sodium salt of the latter. From these substances clear transparent polymers and copolymers have been prepared. Further research along these lines is in progress.

HARDWOOD PULPING

The College has been engaged for over two years in special studies of the preparation of high-grade pulps from hardwoods by the semichemical and mechanical (grinding) processes. Following methods developed at the United States Forest Products Laboratory the College produced hardwood pulps on a semicommercial basis. Special studies have been made on the refining of hardwood chips cooked by semichemical processes. The strength properties of such pulps compare very favorably with regular chemical hardwood pulps and the yields are about 50% greater. These pulps are suitable for use in better grades of printing and catalog papers as well as in a variety of other grades, including glassine.

The study of pulping hardwoods is of great importance to the pulp and paper industry of New York, the Northeast, and the Lake States. The industry in these areas relies to a great extent on imported Canadian spruce pulpwood. The very considerable hardwood stands in these areas have not been used for pulp, because hardwoods do not produce a satisfactory pulp by the ordinary processes which are well adapted to coniferous species. A satisfactory solution to this problem would present the pulp industry with a much needed new source of supply close at hand.

The use of the semichemical process combined with the attrition mill to produce hardwood pulps widens the raw material possibilities and is a partial answer to the problem. However, if hardwoods could be used in the large-tonnage low-cost mechanical process their value to the pulp and paper industry would be great indeed. The problem of substituting hardwoods for spruce in the large-scale production of mechanical pulp is difficult due to the relatively short fiber in hardwoods and to the high density of the wood compared to spruce. In fact, the use of hardwoods other than aspen by the well-known mechanical process to produce a pulp which even approaches that of spruce in quality has never been achieved by industry. However, the results obtained through the studies at the New York State College of Forestry have exceeded expectations. Hardwood pulps have been prepared from yellow birch, aspen, beech, and hard maple in high yields and with low power consumption and which have excellent strength and color properties.

The process involves a chemical pretreatment of the four-foot bolts of wood. This is followed by grinding on an ordinary pulpstone. These hardwood pulps may be substituted successfully for spruce mechanical pulp in most grades of paper. They have strength properties three to four times as great as ordinary spruce groundwood and lie midway between spruce groundwood and unbleached sulphite pulps in strength and fiber characteristics. The hardwood pulps are obtained in yields of 85 to 90%. The power required for grinding is about one-half that necessary for pulping spruce wood. Furthermore, the production rate exceeds spruce pulp production in a given time period by 100%. The high density of most hardwoods results in a yield of pulp which exceeds that from conifers by about 700 pounds per cord of wood. For example, birch will produce about 2900 pounds of pretreated groundwood per cord compared to not over 2200 pounds of ordinary groundwood from spruce. The value of this additional pulp is estimated to be several times the cost of the mild chemical pretreatments.

DETERIORATION IN WOOD

The College has been carrying on for many years various studies in wood decay. An outstanding fundamental study is the taxonomy of the genus *Poria*, one of the most widespread and important of wood-destroying fungi. Dr. J. L. Lowe is now recognized as an international authority on this genus and has collections from all over the world. The College has been studying in detail the organisms responsible for decay in houses, farm buildings, greenhouse benches and flats, storage sheds, and other buildings during the past two years. Over 500 collections have been made in New York State and the identification of preservative treatments to prevent decay of wood in various uses have been tested and results will soon be made available. Recommendations will be made according to uses, viz., silos and farm structures, greenhouse benches and flats, boats, houses, storage buildings, etc.

Recently a study of the variations in the decay resistance of white oak was completed. It was found in the specimens studied that there is increased resistance to decay radially from the pith through the outer heartwood. Relationships were found between certain chemical and physical properties of the wood and its decay resistance. The hot-water extractives were found to be highly toxic to the common wood-destroying fungus. The toxicity of the hot-water extractives was found to vary with radial position in the tree. The toxic materials were shown to be a part of the tannin complex, for the removal of the tannins from the hot-water extractives eliminated their toxicity to fungus in culture.

Last fall a study of insect damage to houses and wood in service was started. Already the insects primarily responsible for damage to wood in service in New York State have been determined and classified. The methods of treatment to prevent such damage are now being investigated. The results of the decay and insect damage studies are expected to be of considerable practical value for all types of wood uses in New York State and the Northeast.

RESEARCH ORGANIZATION AND FACILITIES

The New York State College of Forestry has an active academic staff of 61, many of whom are engaged in research, and a full-time research staff of 13, not including assistants. There are also 68 graduate students at present, most of whom are engaged in research under the direction of the faculty.

The facilities of the College for research are extensive and varied. The College operates and manages several forest areas for research and demonstration, including the Pack Demonstration Forest of 2211 acres at Warrensburg, the Pack Experimental Forest of 964 acres and the Ranger School Forest of 2330 acres on Cranberry Lake, the Huntington Wildlife Forest of 14,984 acres at Newcomb, and smaller areas near Syracuse. At Syracuse the College has research laboratories for forest botany and pathology, forest entomology, forest zoology and wildlife, silviculture

and soils, forest management, landscape and recreational management, wood technology, wood utilization, wood chemistry and plastics, and pulp and paper technology.

The wood utilization facilities include a portable sawmill, preservation equipment, a dry kiln of 2000 board feet capacity, a wood-working laboratory, gluing and pressing equipment, dielectric units for radio frequency heating, etc. The pilot plant of the pulp and paper laboratory includes a 65-cubic foot stainless steel digester, beaters, refiners, a 52-inch wide combination Fourdrinier and cylinder paper machine, a mechanical pulp grinder, a hydrapulper, and other accessory equipment to make a complete pulp and paper semicommercial mill. The wood chemistry and plastics laboratories are equipped with many types of research instruments, including high-vacuum stills, ultraviolet absorption apparatus, an x ray machine, and plastic mixing and molding equipment.

There is a growing realization of the need for increased research in forestry and with forest products in order that the greatest good may result from our forest resources. In recognition of this need a separate research budget has been set up at the College. This has permitted the organization of a full-time research staff administered by a Director of Research. It is expected that the research function of the College will grow steadily. The College plans further to develop and maintain effective cooperative relationships with forest operators, manufacturers of forest products and various private, state, and federal agencies having responsibilities relating to reseach in forestry and forest products.

The Packaging Adhesion Problem

FRANK MOREHOUSE

At a meeting of The Metropolitan Group of The TAPPI Empire State Section, held during the past year there was a panel discussion on Adhesives for Containers.

It was realized by the program committee of the section that a very large percentage of the people who buy paper and paperboard do so with the intention of pasting it together to form some sort of a package or container for carrying merchandise. The committee anticipated, therefore, that it would be of interest to the members to hear a group of technical men from several different adhesives manufacturing concerns in a discussion of the various aspects of this rather important subject. In accordance with this thought, one meeting was devoted to the subject of adhesives and several of the well-known manufacturers sent their representatives to discuss some particular phase of the subject.

All of the speakers on the panel gave very interesting talks, and it was particularly interesting to note that all of them stressed the importance of two fundamental points:

1. It is absolutely necessary to have the right adhesive for a particular job, especially if it is done with the aid of high-speed automatic equipment.

2. When unexpected trouble appears, following a period of successful operation, the sudden failure may be due to: (a) nonuniformity in the particular lot of adhesive being used, (b) nonuniformity in the particular lot of paper or paperboard being used, and/or, (c) mechanical difficulty in the machine itself.

The discussion from the floor at the conclusion of the speakers remarks was long and lively. If the vigorousness of the discussion is any criterion by which to judge the extent of the interest in the subject, it must be concluded that the interest was very keen. The members appeared to be quite ready to agree with the speakers in their contention that the adhesive must be the right one for the job and that it must be uniform from batch to batch to insure uniformly good operating efficiency. However, there appeared to be much doubt as to how to know when they had found the best adhesive for the job, and how to know that it was of uniform quality after they had found it.

This led to a discussion of how one adhesive could be distinguished from another, of the same general type, by laboratory methods. It was pointed out that there are no standard TAPPI methods which enable technical men to make scientific distinctions between different adhesives and no standard methods that enable the user of the adhesive to know whether uniformity from lot to lot is being maintained. The fact was recognized that a limited amount of work had been done by TAPPI in the field of those particular adhesive products that are used as binders for the pigments that are utilized in the manufacture of coated papers. However, this appeared to be about the only TAPPI activity in this tremendously broad field, and the suggestion was made that there was a real need for a TAPPI Adhesive Committee that would cover the entire field of testing methods for all kinds of adhesive products.

The following comments are a brief outline of the author's experiences and views on the subject, and they are presented in the hope that adhesives users and manufacturers will recognize the value of engaging in a cooperative effort in this badly neglected field.

Suppose that the National Biscuit Company, a typical user of adhesives, is planning to start production on a new packaging operation. The production department comes to the laboratory and asks for recommendations on the paper and paperboard to be used and also the adhesive to be used. Ordinarily the laboratory has no difficulty in describing the characteristics of the paper and the paperboard in terms that any paper supplier can understand because such products are tested by standard TAPPI test methods with which every paper supplier is familiar, and they can be described in well-known standard terms. But when we come to the adhesive we are immediately in trouble. Even though several different adhesives are used regularly in the factory, there is no satisfactory way of telling the suppliers what is wanted for the new operation. There are no standard quantitative test figures on the regular adhesives, obtained by the application of standard testing methods, because there are no standard methods.

In this situation the adhesives suppliers are not a bit better off than the plant. They are in the very awkward position of knowing that here is a new opportunity to sell some more glue, if they only knew what to supply. But they do not know what characteristics the new adhesive should have because we, in the laboratory, do not know how to describe those characteristics in standard TAPPI terms.

In such circumstances as these it is necessary to fall back on the old primitive methods of trial and error. Each adhesive supplier sends in what he thinks will be best for the job. The samples, when received at the laboratory, will be as far apart as the poles in their properties. One will be thick and another thin. One will be at high solids content and another low. One will be so alkaline and tacky that it is not possible to spread it on an application roller, and another will be as soft as a cornstarch paste. If the job happens to call for the use of a hot melt product, one will be as hard as a rock and the other as soft as putty.

Having received the samples, it is necessary to try to determine which one of them will work best in the equipment. Usually it is possible to determine by these trials that one is better than the others, but it is almost never exactly right. Perhaps it needs to be a little thicker. How much thicker? We just do not know, because there are no

Frank G. Morehouse, Member TAPPI; Chemist, National Biscuit Co., New York, N. Y.

standard test methods by which to determine the thickness. Then all of the suppliers send in another set of samples, which may or may not be better than the first ones, and the same machine tests are made all over again, and this sort of thing is repeated until finally something that will at least get the new production operation started is obtained.

Now suppose that the plant has been operating reasonably well with this new adhesive for some time, possibly for a period of some weeks or months, and then the sealing operation suddenly fails. The laboratory receives a rather frantic call from the packing floor foreman and goes out into the factory to see what it can do to help. The story is almost always the same. The foreman says that his mechanic assures him that the machine is in perfect adjustment from the mechanical standpoint, and that he is sure that there must be something different about this particular lot of glue. He asks the chemist to take a sample of the glue back to the laboratory and see what is wrong with it. The chemist takes the sample back to the laboratory, but when it comes to seeing what is wrong with it, he is just about as helpless as the mechanic would be because he has no standard laboratory methods by which to determine whether this particular lot of glue is normal or not.

Here again the adhesive supplier is not in any happier situation than the laboratory man. He has received a complaint on his product and yet, as far as he knows, this particular lot of glue was made from the regular ingredients in the regular way. He has a small sample of the glue on file in his factory and it appears to be perfectly normal. He is quite confident that the source of the difficulty must be somewhere else. But the laboratory man insists that he must have something different from the troublesome lot of glue in order to keep up with the production rate, and the adhesives supplier can meet this demand only by starting all over again with another round of trial and error tests. By this time the confusion on the packing floor is considerable and everybody is beginning to be a little bit impatient with everybody else. Needless to say, the prestige of the laboratory man and the glue supplier is not enhanced in the eyes of the production men. They are bound to conclude that the laboratory man and the glue supplier are fumbling around in the dark, and the regrettable fact is that they are right in this conclusion.

In addition to the rather acute type of difficulty described above, which is presumed to have been caused by lack of uniformity in the glue product, there is a less acute form of difficulty with which both the glue user and the glue maker must be concerned and which is also related to nonuniformity. Every manufacturer of adhesives knows that there is bound to be a small amount of variation in his product, from one batch to the next, in spite of his best efforts. This is due to the fact that the raw materials themselves vary slightly from lot to lot, and also to the fact that their large-scale manufacturing processes cannot possibly be controlled with absolute accuracy. Knowing that these small variations are bound to occur, the glue maker is in a constant state of anxiety because he does not know how much variation the user's equipment will stand and therefore he never knows, when he makes a shipment to the user, whether the material will come back as a complaint or not.

Much of this needless anxiety would be eliminated if there were standard methods which could be used to determine in advance how wide these unavoidable glue variations could be without endangering the efficiency of the machine operation. The glue user could apply standard test methods to any suitable number of successive batches of glue and would have no difficulty in learning that when the adhesive was within a certain normal range of values it would almost certainly perform satisfactorily. This information could be passed on to the glue manufacturer and he would know quite definitely that any lot of glue that fell within the range of safety could be shipped out to the user with reasonable expectations of success. If a particular lot was outside of that customer's range, he could ship it to some other user who had reported a wider margin of safety. Many glue users carry on hand-pasting operations which are much less seriously affected by small variations than some machine operations.

A description of difficulties of this kind leads naturally to the question of what might be done to eliminate them. The need for standardization of methods has been stressed and we come now to the question of how to accomplish the desired result.

It is the author's opinion that this is a job for TAPPI There are included in the membership of this organization many large users of paper and paperboard who would unquestionably benefit from a standardization of adhesive testing methods. The number of adhesive makers is smaller, but they too would unquestionably be relieved of many of their troubles if there were some common language in which they could discuss the properties of their products with their customers. TAPPI's contribution to the solution of this problem would be to get these people together, either by increasing the scope of activity of an existing TAPPI committee or by forming a new committee for the purpose. In either case, however, the committee should be made up of both manufacturers and users of adhesives, and the members should be technical men who have an adequate appreciation of the value of standard test methods as well as their limitations.

Such a committee would have to operate in a manner somewhat as follows. It would be necessary for its chairman to establish subcommittees, each one to handle a particular class of adhesive products. One subcommittee would have to handle the aqueous adhesives of the dextrine type, another would have to handle the nonaqueous lacquer types, another the resin emulsions, and so on. The amount of work to be done is large, and it would need to be a large committee with many subdivisions. Each subcommittee would need to keep two main objectives in mind: (1) study all proposed methods with a view to the adoption of suitable ones as standards, and (2) encourage the development of new methods where existing methods are not suitable for adoption as standards.

In connection with the selection of personnel for the committee, it is absolutely necessary that the prospective committeeman be convinced in his own mind that the work really needs to be done. A half-hearted approach will be of no value, because the work that is contemplated is difficult and large in volume.

The Practical Aspects of Adhesive Testing

KENYON LOOMIS

Mr. Morehouse has given a review of a series of problems which have received considerable thought by both suppliers and users of adhesives. The problem is one for industry generally. With cooperation, progress should be possible. The Technical Committee for the Adhesives Manufacturers Association has discussed this problem, and the author is pleased, as industry consultant for the association, to comment on it.

It is important that there is a clear understanding of the word adhesive which has a different meaning depending upon where it is used. To the technical groups represented here, there are at least three points of view that should be kept in mind.

Kenyon Loomis, Industry Consultant, Adhesives Mfgr. Assoc. of Am., New York, N. Y.

1. Paper coaters will think of the binder they use in their coating mixes to hold clay or pigment to the paper stock. In this case, they may think in terms of starch which is enzyme converted, chlorinated starch, dextrines of various types, proteins, resins, and perhaps other binders as well. The consumer uses the adhesive as an ingredient in his own formulation which more than likely is peculiar to himself or for the equipment and type of coated paper he manufactures. Different mills, with essentially the same types of equipment and manufacturing essentially the same sorts of coated papers, may have entirely different ideas as to what type of adhesive is most suitable for them.

2. A different point of view is represented by those concerns which prepare adhesives or glues from base materials on a relatively large scale for their own use. Reference is made to manufacturers of corrugated paper, tubes, laminating, multiwall bags, and other such large scale operations. Adhesives as used here are of a sort that have been fairly well standardized with not too many ingredients involved, and which can be prepared by means of relatively simple and standardized manufacturing procedures. In each case, the adhesive has been formulated and standardized to meet the particular large scale production requirements of the individual plant. Almost without exception, the adhesives so prepared are used soon after mixing, and in some cases, before they have had a chance to cool thoroughly after being cooked.

3. The third point of view that should be considered in connection with adhesives is that of the packaging man, who is constantly trying to utilize numerous combinations of paper, inks, finishes, and other packaging materials under a variety of conditions, with higher speed machines in order to obtain greater economy, and at the same time a package with more eye appeal. This field of adhesive activity is far removed from the relatively simple and standardized formulations of the group just mentioned.

Consequently, users of adhesives in these three fields of activity will look on the subject of adhesives from entirely different points of view. It is on the third class of adhesives, primarily, to which attention has been focused by the preceding paper. In this field of specialty packaging adhesives, it is understandable that consumers would want to know methods and procedures that will help them better standardize and determine when an adhesive will work, or whether or not an adhesive is at fault when some difficulty arises in their fast production system. It would be both nice and useful to be able to check in the laboratory, by means of entirely reliable testing methods, and determine whether or not a given adhesive was suitable for a certain job. Unfortunately, the manufacture and evaluation of such types of adhesives have not reached that state of scientific development, and at the present time represent more of an art than the result of known, standardized scientific knowledge.

A listing of the various factors related to this over-all problem might enable those who are not too familiar with the difficulties involved to understand why there is an apparent lack of standardization in this field. For example, the following should be borne in mind:

1. The kind of adhesive job involved.
2. The type, speed, and condition of the equipment or machine on which the job is to be done.
3. Type and variations in the paper used.
4. The humidity and temperature of the place where the job is done.
5. The kind and amount of adhesive used.
6. The age of the adhesive used.
7. The tack or stickiness of the adhesive.
8. The viscosity required for the machine operation.
9. The texture of flow properties required of the adhesive.
10. The performance or quality requirements of the job.
11. The quality and experience of the operators doing the job.
12. The hygroscopicity of the adhesive film, in view of the existing weather conditions.
13. The acidity or alkalinity of the adhesive in relationship to the glue pot or papers used.
14. Odor and color of materials used.

It will probably be agreed that even a casual review of these practical factors involved in every packaging operation present a multiplicity of variables, and in many cases they are extremely difficult to control. Some of them depend upon nature and some upon the personal equation. Some of the more important physical properties which influence performance and which one might think could be easily measured, cannot be measured accurately with present techniques. For example, tack is a property which everyone recognizes as the stickiness of an adhesive film, but which no one knows how to measure. Even viscosity, while relatively easy to define, is difficult to measure and interpret. Consistency is perhaps a better word, because what is important in adhesives is a combination of true viscosity, plastic flow, and in some cases a certain amount of gelling tendency. A proper evaluation of an adhesive from these points of view will many times tax the judgment of an adhesive engineer of many years experience.

Attempts have been made to test or evaluate adhesives by means of chemical and physical tests such as pH, titration, viscosity, and the like. Such tests do have a certain amount of usefulness, particularly in determining whether or not a given sample or shipment of material is what it is supposed to be. However, it is important that all the factors just enumerated be kept in mind when the entire adhesive job is being considered. Just as it is possible for a poor cook to take the best of ingredients and prepare an unappetizing dish, so it is possible for a careless or improperly trained operator to produce an unsatisfactory commerical adhesive job, with a perfectly good standard adhesive meeting normal, chemical, and physical tests.

Some chemists place great confidence upon the chemical and physical values which they have determined after analyzing a particular adhesive which has been found to work satisfactorily on their equipment. They tend to conclude that any adhesive which would stand a chance of functioning even as well, must conform with those chemical and physical tests. Such is not a fair conclusion, because all of the factors have not been considered, as well as the importance of different manufacturing procedures used in making particular adhesives for the job.

Although this subject is complex and difficult to define and standardize, it may be possible for a group of interested parties, representing the various factors involved, to make some progress by pooling their knowledge and know-how. This is being done by other groups such as the Adhesives Committee of the ASTM and of the Packaging Institute. The Adhesives Manufacturers Association's Technical Committee is cooperating with those committees. It might be helpful if all of these various groups, including any committee or committees which TAPPI may choose to appoint, would cooperate among themselves, so that there would be a minimum of duplication. By combining various efforts, it should be possible to do a better job and perhaps arrive at some testing methods which would be recognized generally as reference methods. It is perhaps too much to hope that such committees can extend knowledge to the point that a complete correlation of all of the factors involved in a given adhesive operation would be obtained. On the other hand, if a few testing methods could be recognized, it might be helpful both to manufacturers and consumers of adhesives, and thus enable them to have at least a few words in a common language.

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Calendar of TAPPI Meetings

NATIONAL

Annual Meeting: Commodore Hotel, New York, N. Y., February 20–23, 1950.

Fundamental Research Conference: Chateau Frontenac, Quebec, P. Q., May 29–30, 1950. Symposium: "The Papermaking Properties of Fibers." (Joint Meeting with Technical Section, Canadian Pulp and Paper Association).

LOCAL SECTIONS

PACIFIC SECTION:
February 7, 1950, Everett, Wash.
April 6, 1950, Camas, Wash.

EMPIRE STATE SECTION:
Metropolitan Group:
January 10, 1950, Fraunces Tavern, New York, N. Y.
March 14, 1950, Fraunces Tavern, New York, N. Y.
Northern New York Group:
January 12, 1950, Woodruff Hotel, Watertown, N. Y.
February 9, 1950, Woodruff Hotel, Watertown, N. Y.
March 9, 1950, Woodruff Hotel, Watertown, N. Y.

DELAWARE VALLEY SECTION:
January 26, 1950, Engineers Club, Philadelphia, Pa.
March 23, 1950, Engineers Club, Philadelphia, Pa.

OHIO SECTION:
January 10, 1950, Manchester Hotel, Middletown, Ohio
February 9, 1950, Manchester Hotel, Middletown, Ohio
March 14, 1950, Manchester Hotel, Middletown, Ohio

MAINE-NEW HAMPSHIRE SECTION:
June 23–24, 1950, Wentworth-by-the-Sea, Portsmouth, N. H.

KALAMAZOO VALLEY SECTION:
February 2, 1950, Columbia Hotel, Kalamazoo, Mich.
March 2, 1950, Columbia Hotel, Kalamazoo, Mich.

filter runs
in winter . . .

increased
from
11.5 to 20 hours

Longer filter runs during winter months, and better color too, are reported by leading mills using N-Sol Process as a coagulant aid. The filtered water turbidity may be decreased from approximately 1.0 to 0.5.

N-Sol Processes are methods of reacting "N" Silicate with reagents to produce activated silica sol. This, combined with alum as a coagulant, forms a large, tough, dense and rapid settling floc for either horizontal or up-flow systems.

Mills welcome the N-Sol Processes for solving color removal problems, for increasing filter runs, and for decreasing filtered water turbidity.

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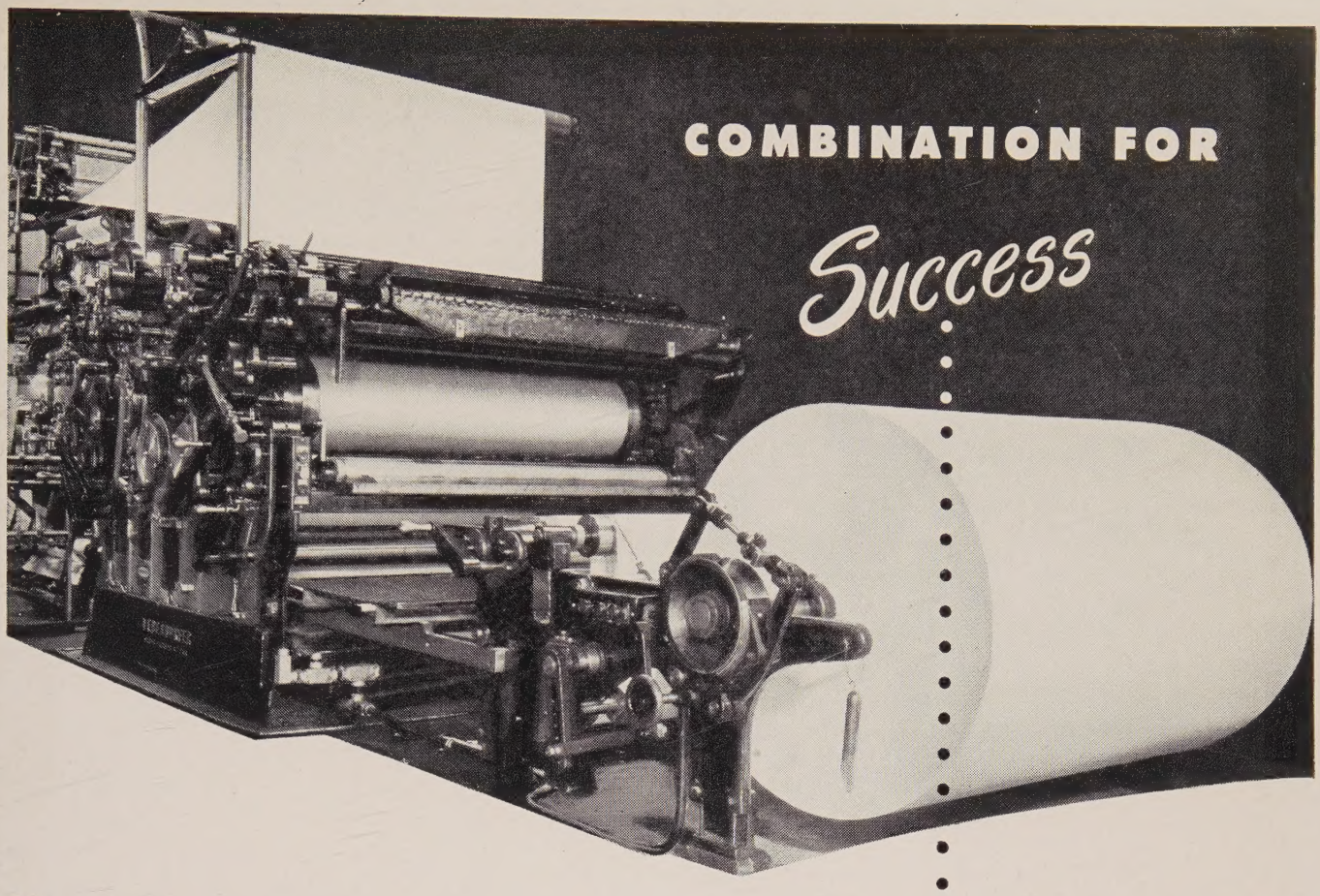

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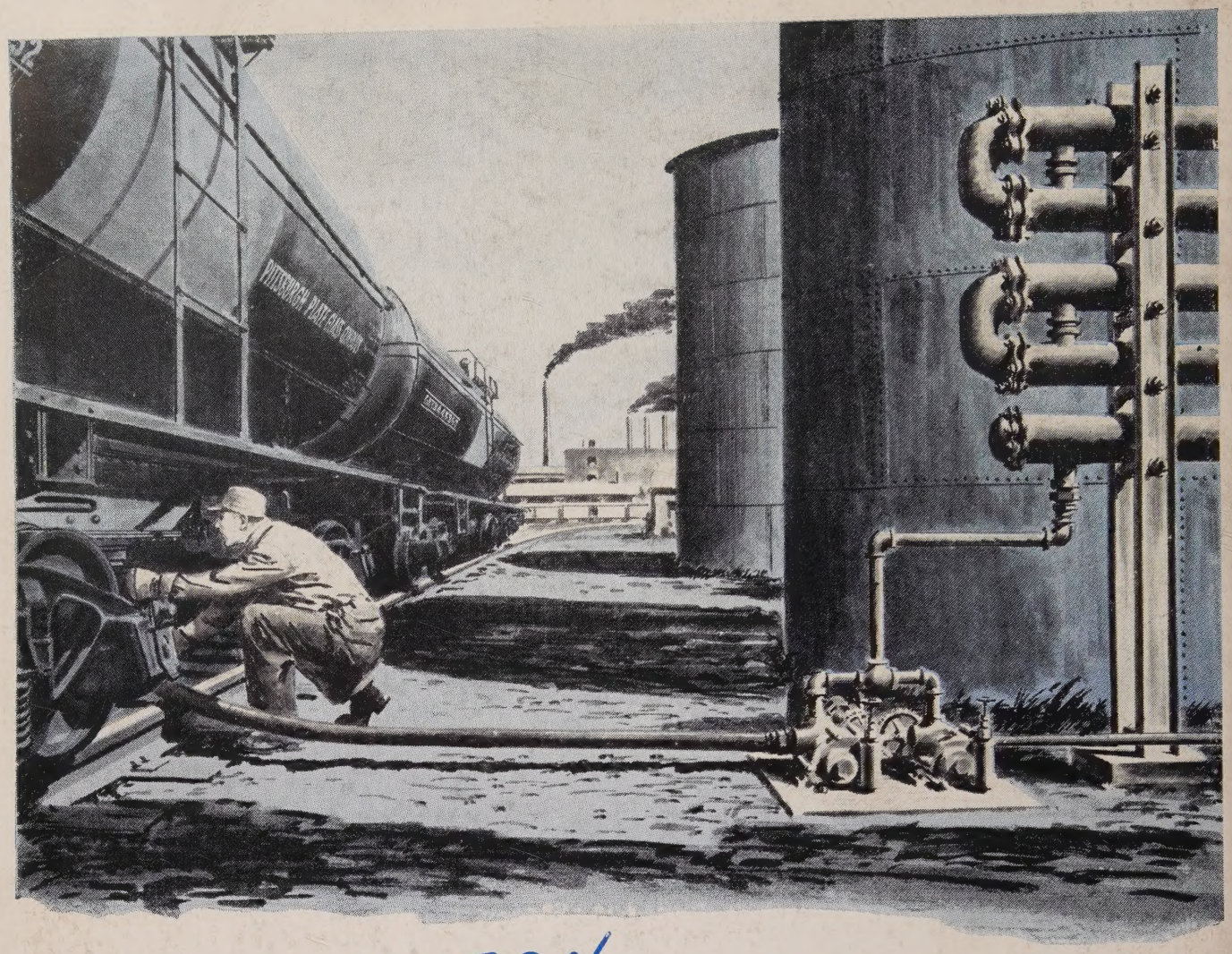

73% vs. 50%

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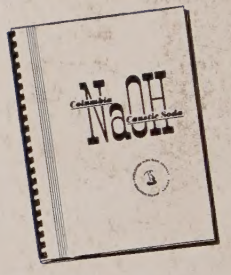

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